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1991 CRC OCTANE NUMBER REQUIREMENT SURVEY

October 1992

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1991 CRC OCTANE NUMBER REQUIREMENT SURVEY
(CRC Project No. CM-123-91)

Prepared by the

1991 Analysis Panel

of the

CRC Octane Number Requirement Survey Group

October 1992

Automotive Vehicle Fuel, Lubricant, and Equipment Research Committee

of the

Coordinating Research Council, Inc.

ABSTRACT

An annual statistical survey of octane number requirements of current model vehicles is conducted by the Coordinating Research Council, Inc. Test data have been obtained by fifteen companies on 262 1991 vehicles including passenger cars and light-duty trucks and vans, of which 105 were equipped with knock sensors. Octane number requirements were determined by testing at maximum-throttle conditions, as well as at part-throttle, with four unleaded fuel series of varying sensitivities, one containing 15 percent methyl tertiary butyl ether. Requirements are expressed as the (R+M)/2 octane number, Research octane number, and Motor octane number of the reference fuel producing knock which was recurrent and repeatable at the lowest audible level. Estimated octane number requirements for the total vehicles are weighted in proportion to the 1991 vehicle model production and/or sales figures. The octane number requirements of 1991 models with average sensitivity unleaded fuels were 85.7 (R+M)/2 octane numbers at the 50 percent satisfaction level, and 90.9 (R+M)/2 octane numbers at the 90 percent satisfaction level. The FBRUM fuel series is analyzed in the same way as the other three fuel series in this report. More detailed comment and analysis of the FBRUM fuel series will be deferred until data from the 1992 Survey can be pooled with the 1991 Survey data for a more statistically significant data set. Comparison with previous Surveys are made in this report.

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I. INTRODUCTION

This is the forty-fifth annual statistical survey of octane requirements of current model vehicles conducted by the Coordinating Research Council, Inc. This Survey studies distributions of vehicle octane requirements as a function of satisfaction levels and fuel sensitivity in a sample representative of 1991 model vehicles. Distributions of vehicle octane requirements are estimated from these data. The effect of fuel sensitivity, which is the difference between Research octane number (RON) and Motor octane number (MON), is investigated by using two full-boiling range fuel series and the primary reference fuel series. A third full-boiling range fuel series containing 15 percent methyl tertiary butyl ether (MTBE) was compared with the full-boiling range average sensitivity reference fuel. This was done to investigate vehicle response to an oxygenated fuel. This is done because vehicles do not respond to RON and MON in the same way.

Knock sensors enable engines to adapt to fuels of varying octane numbers which can result in lowest audible knock occurring over a range of octane numbers; however, only the high end of this range is determined for each knock-sensor-equipped vehicle and used for the distribution calculations.

The data in this Survey are obtained by trained raters under controlled conditions. For some vehicles, information on the owner's perception of vehicle knock and the owner's current choice of gasoline octane are available. A comparison between the trained rater's and customer's report of knock on tank fuel is presented, and trends are shown.

Fifteen companies participated in this Survey; they are listed in Appendix A. Members of the CRC Octane Number Requirement Survey Analysis Panel are identified in Appendix B.

II. SUMMARY

Octane number requirements were determined on 262 1991 model year vehicles, including 206 passenger cars and 56 light-duty trucks and vans. One hundred five of the test vehicles were equipped with knock sensors. Estimated octane number requirements for the vehicle populations are weighted in proportion to the 1991 vehicle model production and/or sales data. Octane number requirements for the 1991 models and changes from 1990 for the four weighted vehicle population groups at the 50 percent and 90 percent satisfaction levels using FBRU (full-boiling range unleaded) and FBRUM (full-boiling range unleaded containing 15 percent MTBE) fuels are summarized below. Since this was the first Survey year for the FBRUM series, there is no comparison to 1990.

FBRU AND FBRUM (R+M)/2 OCTANE NUMBER REQUIREMENTS AND 95% CONFIDENCE LEVELS

1991 AND CHANGES FROM 1990

Weighted Population	FBRU Octane Requirement	Δ from 1990	FBRUM** Octane Requirement
	50% Satisfaction		
Total Vehicles (40.1%)*	85.7±0.5	+0.3	84.9
Total Cars (34.5%)*	85.3±0.5	+0.3	84.5
Total Trucks and Vans (60.7%)*	86.8±1.2	+1.0	85.9
Total Knock-Sensor Vehicles	84.2±1.0	-1.3	83.9
	90% Satisfaction		
Total Vehicles (40.1)*	90.9±0.6	+1.7	90.4
Total Cars (34.5)*	90.2±0.7	+1.0	89.7
Total Trucks and Vans (60.7)*	93.9±1.6	+4.9	95.6
Total Knock-Sensor Vehicles	90.5±1.3	+0.8	95.8

* Percent of knock-sensor-equipped vehicles tested within the associated population.

** Confidence Levels not shown for FBRUM fuels.

Octane number requirements of the total 1991 vehicle population increased by 0.3 (R+M)/2 at 50 percent satisfaction and increased by 1.7 (R+M)/2 at 90 percent satisfaction compared with 1990 on FBRU fuels. Octane requirements of 1991 knock-sensor vehicles decreased by 1.3 (R+M)/2 at 50 percent and increased by 0.8 (R+M)/2 at 90 percent satisfaction compared with 1990. Changes in these distributions are not significant at the 95 percent confidence level.

Part-throttle octane requirements were equal to or higher than the maximum-throttle octane requirements on 34 percent of all 1991 vehicles with FBRU fuels (85 of 254 vehicles). This compares with 23 percent of all 1990 vehicles with part-throttle requirement on FBRU fuels.

In the 1991 Survey, 44 percent of the owner-operated vehicles tested knocked on tank fuel.

The 1991 Survey included sufficient data for four specific models to be analyzed separately as select models. Two select models were equipped with knock sensors. Octane requirements for the select models at the 50 percent and 90 percent satisfaction levels for FBRU fuels are summarized in the following table.

SELECT MODELS
MAXIMUM FBRU OCTANE NUMBER REQUIREMENTS

		(R+M)/2	
Select Model	No. Tested	50% Sat.	90% Sat.
A	11	85.7	89.3
B	11	90.9	96.9
C	14	86.9	93.0
D	18	82.3	87.7

III. TEST VEHICLES

This year's Survey tested a total of 262 1991 model vehicles. The analysis of the data included 206 passenger cars and 56 light-duty trucks and vans. Also included are 105 knock sensor-equipped vehicles (71 cars and 34 trucks). Beginning with the 1987 Survey, test vehicles are divided into four main categories:

(1) Total Vehicles, which includes all US and imported passenger cars and light-duty trucks and vans

(2) Total Cars, which includes all US and imported passenger cars

(3) Total Trucks and Vans, which includes all US and imported light-duty trucks and vans

(4) Total Knock-Sensor Vehicles, which includes all knock-sensor-equipped US and imported passenger cars and light-duty trucks and vans.

In the 1991 Survey, 85 percent of the transmissions were automatic. Twenty-seven percent of the automatics were three-speeds, and the rest four-speeds. The manual transmissions were divided into 3 percent four-speeds, 94 percent five-speeds and 3 percent six-speeds. Ninety-seven percent of the surveyed vehicles were air-conditioned.

The select models shown in Table 1 include four additional models, none of which were included in the program proposal (Table D-1 of Appendix D). Although not appearing as select models in the program proposal, these four models are included as select models because ten or more vehicles per model were tested. Due to the small Survey size, manual- and automatic-transmission vehicles were pooled to form the select models.

Table 2 shows the distribution of odometer mileage for both the 1991 and 1990 Surveys. The 1991 distribution is shown as a bar chart in Figure 1. The average odometer mileage was 14,112. The average displacement of those vehicles tested in 1991 was 3.1, the same as in 1990. The average compression ratio of those vehicles tested in 1991 was 9.0, also the same as in 1990.

Trends in the sales-weighted average compression ratio, engine displacement, and knock-sensor penetration for the US vehicle population over the last five model years are shown below. Also included are the percent of vehicles tested in this Survey which have automatic transmissions and air conditioners.

1991 ONR SURVEY TEST VEHICLE DATA

Average Vehicle Parameters

	Sales Weighted			Percent of Vehicles Tested	
Model Year	Displacement (liters)	Compression Ratio	% Knock Sensor	Automatic Transmissions	Air Conditioners
1991	3.1	9.0	38.2	85	97
1990	3.1	9.0	42.9	87	97
1989	3.1	9.0	40.2	86	97
1988	3.0	9.0	39.6	82	92
1987	2.9	9.0	35.0	81	89

The basic spark timing was adjusted to the manufacturer's recommended setting (within ±1°) prior to testing. A total of five vehicles were adjusted; all were two or more degrees off from the manufacturer's setting. The number of vehicles and their deviation in spark setting are shown in Table 3.

Participants were requested to rate specific vehicle models in a pattern which would minimize data bias due to differences among testing laboratories and vehicles. To accomplish this, the United States and Canada were divided into four geographical areas, and companies within each geographical area were requested to test specific vehicles.

IV. REFERENCE FUELS

Four series of reference fuels were used in the 1991 Survey:

- Primary Reference (PR) Fuels
- Average-Sensitivity Full-Boiling Range Unleaded (FBRU) Reference Fuels with sensitivities similar to those of commercial gasoline
- High-Sensitivity Full-Boiling Range Unleaded (FBRSU) Reference Fuels with sensitivities about two octane numbers higher than the FBRU fuels.
- Average-Sensitivity FBRU Reference Fuels with 15 percent methyl tertiary butyl ether (MTBE) added (FBRUM).

A. PR Fuels

Isooctane and normal heptane, meeting ASTM specifications, were blended in two octane number increments from 76 to 82 octane numbers, and in one octane number increments from 82 to 100 octane numbers.

B. FBRU Reference Fuels

FBRU fuels were prepared from three base blends (RMFD-377-91/92, RMFD-378-91/92, and RMFD-379-91/92) in two octane number increments from 80 to 84 RON, and in one octane number increments from 84 to 103 RON. The base blends were prepared from normal refinery components. Inspection data furnished by the supplier are shown in Appendix C, Table C-1. The composition and average laboratory octane data for the 1991/1992 FBRU reference fuel series are presented in Appendix C, Table C-2.

C. FBRSU Reference Fuels

FBRSU fuels were prepared from three base blends (RMFD-380-91/92 RMFD-381-91/92, and RMFD-382-91/92) in two octane number increments from 80 to 84 RON, and in one octane number increments from 84 to 103 RON. The base blends were prepared from normal refinery components. Inspection data furnished by the supplier are shown in Appendix C, Table C-3. The laboratory blending octane data for the 1991/1992 FBRSU reference fuels are presented in Appendix C, Table C-4.

D. FBRUM Reference Fuels

FBRUM fuels were prepared from three base blends (RMFD 383-91/92, RMFD 384-91/92, and RMFD 385-91/92) in one octane number increments from 84 to 105 RON. The base blends were prepared from the FBRU series fuels with 15 percent methyl tertiary butyl ether (MTBE) added. Inspection data furnished by the supplier as shown in Appendix C, Table C-5. The laboratory blending octane data for the 1991/1992 FBRUM reference fuels are shown in Appendix C, Table C-6.

V. TEST TECHNIQUE

The test technique (CRC Designation E-15-91, Attachment 2 of Appendix D) specified that octane number requirements be determined at level road acceleration conditions. The order of fuel testing was tank fuel, FBRSU fuels, FBRU fuels, PR fuels, and FBRUM fuels. Knocking tendencies were investigated using both maximum-throttle and part-throttle acceleration techniques.* Part-throttle was investigated in each vehicle to determine if the part-throttle requirement was higher or equal to the maximum-throttle requirement with all three fuel series. Part-throttle requirements were also determined with FBRU fuels down to four Research octane numbers below the requirement at maximum-throttle.

The octane number requirement of a vehicle is defined as the octane number of the highest octane test fuel producing borderline knock. This requirement is defined at either maximum- or part-throttle acceleration conditions. Requirements are expressed as the (R+M)/2 octane number, Research octane number (RON), and Motor octane number (MON) of the reference fuel which produces knock that is recurrent and repeatable at the lowest audible level.

* Maximum-throttle is either full-throttle for manual transmissions or widest throttle position (detent) that does not cause the transmission to downshift for automatic transmissions.

Of the fifteen laboratories participating in the 1991 Survey, two used level roads and thirteen used chassis dynamometers. Eighty-four percent of the vehicles were tested on chassis dynamometers.

Average test temperature was 68°F, with a barometric pressure average of 29.72 inches Hg and average humidity of 50 grains per pound. Test conditions for individual observations are reported in Appendix E.

The table below shows the average test conditions and the average odometer readings for the last five Surveys.

Average Ambient Test Conditions

Year	Temperature, F°	Barometric Pressure, inches Hg	Humidity, grains per pound	Mileage
1991	68	29.72	50	14112
1990	74	29.77	63	11782
1989	69	29.75	58	12772
1988	70	29.84	57	12407
1987	67	29.85	49	13720

There is general agreement that ambient temperature, pressure, and humidity can influence the octane number requirement of a vehicle at any time. [1,2] Octane requirement increases as temperature and pressure increase, and as humidity decreases. The coefficients of these effects are difficult to determine and may be dependent upon the vehicle.

VI. DISCUSSION OF RESULTS

A. Distribution of Octane Number Requirements

The octane number requirement data were used to prepare satisfaction curves and tables for the following samples of 1991 model vehicles:

(1) Total Vehicles,
(2) Total Cars,
(3) Total Trucks,
(4) Total Knock-Sensor Vehicles.

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(1) B. D. Keller, J. H. Steury, T. O. Wagner, SAE Paper 780668 (1978)

(2) H. A, Bigley, Jr., B. D. Keller and M. G. Kloppe, SAE Paper 710675 (1971).

(R+M)/2, RON, and MON requirements and 95 percent confidence limits for the four categories at 50 percent and 90 percent satisfaction are shown in Table 4. In preparing the curves and tables, the octane number requirement data were weighted in accordance with final 1991 model-year production and/or sales figures. Each curve and table, therefore, provides an estimate of the distribution of octane number requirements of the appropriate vehicle population on the road. The procedure for assigning weighting factors and for calculating the octane number requirement distributions is described in Appendix F.

Vehicles equipped with knock sensors were included in the 1991 models tested. All vehicles with knock sensors were tested for octane number requirements.

Requirements are expressed as the (R+M)/2, Research, and Motor octane numbers of the reference fuel which produced knock that was recurrent and repeatable at the lowest audible level.

Round-off techniques are described in Appendix F. The methods for computing confidence limits of octane number requirement distribution are described in Appendix G.

1. Total Vehicles

In the 1991 Survey, octane number requirements were determined on 255 vehicles with PR fuels, 262 vehicles with FBRU fuels, 262 vehicles with FBRSU fuels, and 255 vehicles with FBRUM fuels. One hundred five of the vehicles were equipped with knock sensors.

(R+M)/2 octane number requirements for all four reference fuels are shown in Figures 2, 3, 4 and 5. The (R+M)/2 octane number requirements for the three hydrocarbon-only reference fuels are plotted in Figure 6 and the oxygenated fuels in Figure 7. The octane number requirement distributions for FBRU and FBRSU fuels are similar. (R+M)/2, Research, and Motor octane number requirements for the hydrocarbon-only fuels are listed in Table 5 and for the oxygenated fuels in Table 6. The 50 percent and 90 percent satisfaction level requirements are:

OCTANE NUMBER REQUIREMENTS

(Total Vehicles)

Fuel	50% Satisfied (R+M)/2	50% Satisfied RON	50% Satisfied MON	90% Satisfied (R+M)/2	90% Satisfied RON	90% Satisfied MON
PR	88.2	88.2	88.2	94.1	94.1	94.1
FBRU	85.7	89.8	81.7	90.9	96.0	85.8
FBRSU	85.7	91.1	80.3	91.5	97.8	85.1
FBRUM	84.9	88.2	81.7	90.4	95.5	85.3

Differences between 1991 and 1990 Survey maximum (R+M)/2, Research, and Motor octane number requirements are also shown in Table 5 for the three hydrocarbon-only fuel series. Distributions of the 1991 and 1990 maximum (R+M)/2 requirements are shown in Figure 8 for FBRU fuels. The differences at the 50 percent and 90 percent satisfaction levels are:

DIFFERENCES BETWEEN 1991 AND 1990
OCTANE NUMBER REQUIREMENTS

(Total Vehicles)

Fuel	50% Satisfied (R+M)/2	50% Satisfied RON	50% Satisfied MON	90% Satisfied (R+M)/2	90% Satisfied RON	90% Satisfied MON
PR	0.2	0.2	0.2	1.9	1.9	1.9
FBRU	0.3	0.5	0.2	1.7	2.1	1.4
FBRSU	0.7	1.1	0.3	2.4	2.8	1.8
FBRUM			NOT RUN IN 1990			

Confidence limits for octane number requirement distributions are given in Table 4 (See Appendix G, Table G-1). The yearly differences at the 90 percent satisfaction level for all fuels are significant at the 95 percent confidence level.

2. <u>Total Cars</u>

Octane number requirements were determined on 199 cars with PR fuels, 206 cars with FBRU fuels, 206 cars with FBRSU fuels, and 200 cars with FBRUM fuels.

(R+M)/2, Research, and Motor octane number requirements for the three hydrocarbon-only fuel series are given in Table 7 and for the oxygenated fuels in Table 8. The (R+M)/2 octane number requirement distributions for all three hydrocarbon-only reference fuel series are plotted in Figure 9 and the oxygenated fuels in Figure 10. Octane number requirements at the 50 percent and 90 percent satisfaction levels are:

OCTANE NUMBER REQUIREMENTS

(Total Cars)

Fuel	50% Satisfied (R+M)/2	50% Satisfied RON	50% Satisfied MON	90% Satisfied (R+M)/2	90% Satisfied RON	90% Satisfied MON
PR	87.6	87.6	87.6	92.7	92.7	92.7
FBRU	85.3	89.2	81.3	90.2	95.2	85.2
FBRSU	85.5	90.8	80.1	90.9	97.1	84.6
FBRUM	84.5	87.6	81.4	89.7	94.6	84.9

Differences between the 1991 and 1990 Survey (R+M)/2, Research and Motor octane number requirements are also shown in Table 7 for PR, FBRU, and FBRSU fuels. Distributions of the 1991 and 1990 (R+M)/2 requirements are shown in Figure 11 for FBRU fuels. Differences between 1991 and 1990 data at the 50 percent and 90 percent satisfaction levels are:

DIFFERENCES BETWEEN 1991 AND 1990
OCTANE NUMBER REQUIREMENTS

(Total Cars)

Fuel	50% Satisfied (R+M)/2	50% Satisfied RON	50% Satisfied MON	90% Satisfied (R+M)/2	90% Satisfied RON	90% Satisfied MON
PR	0.3	0.3	0.3	0.7	0.7	0.7
FBRU	0.3	0.4	0.1	1.0	1.2	0.7
FBRSU	0.7	1.0	0.2	1.6	2.0	1.2
FBRUM	NOT RUN IN 1990					

Confidence limits for octane number requirement distributions of 1991 total cars are given in Table 4. The yearly changes for the total car population are significant at 90 percent satisfaction at the 95 percent confidence level.

3. Total Trucks and Vans

Octane number requirements were determined on 56 light-duty trucks and vans with PR fuels, 56 with FBRU and FBRSU fuels and 55 with FBRUM fuels. (R+M)/2 octane number requirements for the three hydrocarbon-only reference fuel series are plotted in Figure 12 and the oxygenated fuels in Figure 13. (R+M)/2, Research, and Motor octane number requirements for the three fuel series are given in Table 9, and for the oxygenated fuels in Table 10. The 50 percent and 90 percent satisfaction level octane number requirements are:

OCTANE NUMBER REQUIREMENTS

(Total Trucks)

Fuel	50% Satisfied (R+M)/2	50% Satisfied RON	50% Satisfied MON	90% Satisfied (R+M)/2	90% Satisfied RON	90% Satisfied MON
PR	89.8	89.8	89.8	98.2	98.2	98.2
FBRU	86.8	91.0	82.5	93.9	99.4	88.4
FBRSU	86.4	92.0	80.7	92.6	99.0	86.1
FBRUM	85.9	89.4	82.3	95.6	101.6	89.7

Differences between the (R+M)/2, Research, and Motor octane number requirements of trucks in the 1991 and 1990 Surveys are also given in Table 9 for the three hydrocarbon-only fuel series. The differences at the 50 percent and 90 percent satisfaction levels are:

DIFFERENCES BETWEEN 1991 AND 1990
OCTANE NUMBER REQUIREMENTS

(Total Trucks)

Fuel	50% Satisfied (R+M)/2	50% Satisfied RON	50% Satisfied MON	90% Satisfied (R+M)/2	90% Satisfied RON	90% Satisfied MON
PR	0.9	0.9	0.9	5.7	5.7	5.7
FBRU	1.0	1.2	0.7	4.9	5.7	4.1
FBRSU	1.1	1.6	0.5	3.7	4.3	3.0
FBRUM	NOT RUN IN 1990					

Distributions of the 1991 and 1990 (R+M)/2 requirements are shown in Figure 14 for FBRU fuels.

Confidence limits for octane number requirement distributions of 1991 trucks are tabulated in Table 4. The yearly differences for the truck and van population at 90 percent satisfaction are significant at the 95 percent confidence level.

4. Total Knock-Sensor Vehicles

Octane number requirements were determined on 102 vehicles containing knock sensors with PR fuels, 105 vehicles with FBRU and FBRSU fuels, and 103 vehicles with FBRUM fuels.

The distributions of (R+M)/2 octane number requirements are shown in Figure 15 for the three hydrocarbon-only fuel series and in Figure 16 for the oxygenated fuel series. (R+M)/2, Research, and Motor octane number requirements for the three hydrocarbon-only fuel series are given in Table 11, and for the oxygenated fuels series in Table 12. Octane number requirements for the 50 percent and 90 percent satisfaction levels are:

OCTANE NUMBER REQUIREMENTS

(Total Knock-Sensor Vehicles)

	50% Satisfied			90% Satisfied		
Fuel	(R+M)/2	RON	MON	(R+M)/2	RON	MON
PR	87.0	87.0	87.0	93.9	93.9	93.9
FBRU	84.2	88.0	80.5	90.5	95.6	85.5
FBRSU	83.6	88.6	78.5	91.4	97.7	85.1
FBRUM	83.9	86.9	81.0	89.5	94.2	84.7

Differences between 1991 and 1990 Survey (R+M)/2, Research, and Motor octane number requirements are also shown in Table 11. Distributions of (R+M)/2 octane number requirements are shown in Figure 17 for FBRU fuels. The differences at the 50 percent and 90 percent satisfaction levels are:

DIFFERENCES BETWEEN 1991 AND 1990
OCTANE NUMBER REQUIREMENTS

(Total Knock-Sensor Vehicles)

	50% Satisfied			90% Satisfied		
Fuel	(R+M)/2	RON	MON	(R+M)/2	RON	MON
PR	-1.1	-1.1	-1.1	1.7	1.7	1.7
FBRU	-1.3	-1.6	-1.1	0.8	1.1	0.6
FBRSU	-1.5	-1.4	-1.5	1.9	2.3	1.5
FBRUM			NOT RUN IN 1990			

Confidence limits for octane number requirement distributions of 1991 knock-sensor vehicles are given in Table 4.

The yearly difference for the total knock-sensor vehicle population is significant at 50 percent satisfaction for PR fuels, at 50 percent satisfaction for (R+M)/2 only for FBRU fuels, and at 50 percent satisfaction for MON only for FBRSU fuels at the 95 percent confidence level. The yearly difference for total knock-sensor vehicles is not significant at 90 percent satisfaction at the 95 percent confidence level.

5. FBRUM Fuel Series

The difference in the (R+M)/2 octane number requirement between the FBRU and FBRUM series for the total vehicle population has not been shown to be statistically different at the 95 percent confidence level, at either 50 percent or 90 percent satisfaction. A plot of the data, Figure 7, suggests that there may be a difference in satisfaction at 87 (R+M)/2 that is not there at 91 (R+M)/2. This observation may be an artifact of a statistically smaller than required data set. Although data on the three remaining weighted populations have been included in the above sections, comment and analysis will be deferred at this time. The 1992 Survey data will be pooled with the 1991 Survey data for a more powerful test of statistical significance of the FBRUM series.

B. Octane Number Requirement Trends

Trends over the last five years in the sales-weighted octane number requirements of the four vehicle categories analyzed in this report are given in the following table:

FBRU (R+M)/2 OCTANE NUMBER REQUIREMENTS
1987 TO 1991

Weighted Population	1991	1990	1989	1988	1987
50% Satisfaction					
Total Vehicles	85.7	85.4	85.1	84.7	85.7
Total Cars	85.3	85.0	84.8	84.7	85.4
Total Trucks	86.8	85.8	85.8	84.8	86.3
Total Knock-Sensor Vehicles	84.2	85.5	85.4	85.0	86.6
90% Satisfaction					
Total Vehicles	90.9	89.2	89.2	89.3	90.5
Total Cars	90.2	89.2	89.2	89.2	90.4
Total Trucks	93.9	89.0	89.2	89.6	91.6
Total Knock-Sensor Vehicles	90.5	89.7	89.7	90.2	91.9

C. Part-Throttle Requirements

Part-throttle octane requirements were equal to or higher than the maximum-throttle octane requirements on 33 percent of all 1991 vehicles with FBRU fuels (85 of 254 vehicles). This compares with 23 percent in 1990.

D. Select Models

Select models, representing four engine driveline combinations, were tested. The select models tested in this year's Survey included two knock-sensor-equipped models. The specifications of the select models are in Table 1.

Octane number requirements for each select model at various satisfaction levels are listed in Tables 13 through 16.

E. Tank Fuel

Tank fuel was tested for incidence of knock on all vehicles. Owners' questionnaires, however, were obtained only when the vehicle tested had a regular driver and the spark timing was not reset.

1. Owner/Rater Comparisons of Tank Fuel Knock

For 55 vehicles, both owner and rater data were reported, and no adjustments of spark timing were made. The trained raters reported that 44 percent of the owner-operated vehicles knocked, while the owners reported that 13 percent knocked, an owner/rater knock ratio of 0.29. The 44 percent of vehicles found to be knocking by trained raters compares with 22 percent for the 1990 Survey. These owner/rater comparisons of tank fuel knock for 1991, along with previous Survey data back to 1984, are presented in Table 17.

Tank fuel Research and Motor octane number data were reported for a total of 29 vehicles with both owner/rater data and no adjustments of spark timing. Twenty-three vehicles were reported to have tank fuel octane numbers less than 91.0 (R+M)/2. Trained observers reported knock on 61 percent of these, compared with 17 percent for owners. Of the other 6 vehicles having tank fuels greater than or equal to 91.0 (R+M)/2, one knocked according to trained raters, and one owner reported knock.

2. Objectionable Versus Non-Objectionable Tank Fuel Knock

Of the owners reporting tank-fuel knock with vehicles which had no change in spark timing, 29 percent found the knock to be objectionable, as compared to 20 percent in the 1990 Survey. Comparisons of objectionable knock for the 1984 through 1991 Surveys are also given in Table 17.

3. Tank Fuel Knock Reported by Trained Raters

Tank fuel knock observations were reported for 55 of the 262 vehicles tested. The percentages of all 1991 vehicles knocking on tank fuel are shown in Table 18. Knock was observed on 44 percent of the 1991 vehicles tested, compared with 18 percent in the 1990 Survey.

The percentages of select models knocking on tank fuel are shown in Tables 13 through 16.

F. Engine Speed for Octane Number Requirements

Engine speeds at which octane number requirements occurred for each select model are shown in Tables 13 through 16 for PR, FBRU, FBRSU, and FBRUM fuels. Weighted data for all 1991 vehicles are shown in Table 19.

G. Gear Position for Octane Number Requirements

The throttle/gear position for octane number requirements on FBRU fuels is shown in Table 20. Of the 262 vehicles tested, 223 (85 percent) were equipped with automatic transmissions and 39 (15 percent) were equipped with manual transmissions.

Requirements at maximum-throttle occurred in 67 percent of the automatic transmission vehicles (16 percent in fourth gear, 30 percent in third gear, and 21 percent in second gear). Requirements at part-throttle occurred in 30 percent of the automatic transmission vehicles (12 percent in fourth gear, 16 percent in third gear, and 2 percent in second gear).

For manual transmission vehicles, 51 percent had requirements at maximum-throttle (33 percent in fourth gear and 18 percent in third gear) Requirements at part-throttle occurred in 41 percent of manual transmission vehicles (3 percent in fifth gear, 25 percent in fourth gear, and 18 percent in third gear). Fifth gear for five-speed and six-speed manual transmissions was not examined per program instructions.

TABLES

and

FIGURES

TABLE 1

1991 SELECT MODEL SPECIFICATIONS

Model	Knock Sensor	Disp. (L)	Engine Type	Fuel System Type *	Comp. Ratio	Brake HP	Trans-mission
A	N	1.9	L4	P	9.0	88	A4/M5
B	N	4.9	V8	P	9.5	200	A4
C	Y	4.3	V6	T	9.3	160	A4/M5
D	Y	3.1	V6	P	8.8	140	A3/A4

* T = Throttle Body Fuel Injection;

P = Port Fuel Injection;

Individual manufacturers may use different abbreviations.

TABLE 2

DISTRIBUTION OF ODOMETER MILEAGE

FOR TESTED VEHICLES

Mileage	No. of Vehicles Within Mileage Increments	
	1991 Vehicles	1990 Vehicles
0 - 1,999	0	0
2,000 - 3,999	0	0
4,000 - 5,999	1	1
6,000 - 7,999	39	76
8,000 - 9,999	31	86
10,000 - 11,999	37	65
12,000 - 13,999	20	39
14,000 - 15,999	38	32
16,000 - 17,999	37	15
18,000 - 19,999	21	13
20,000 - 24,999	28	20
25,000 - 29,999	8	8
30,000 +	2	1
No. of Vehicles	262	356
Average Mileage	14,112	11,782

TABLE 3

1991 BASIC SPARK TIMING ADJUSTMENTS

Degrees From Manufacturer's Setting	No. of Vehicles +	No. of Vehicles -
1	0	0
2	2	0
3	1	1
4	0	1
	3	2

Total vehicles adjusted	5
Total vehicles not adjusted	157
Total vehicles with timing not adjustable	100

TABLE 4

OCTANE NUMBER REQUIREMENTS WITH 95% CONFIDENCE LIMITS

	Fuel	No. Vehicles	(R+M)/2 50% Sat.	(R+M)/2 90% Sat.	Research Octane No. 50% Sat.	Research Octane No. 90% Sat.	Motor Octane No. 50% Sat.	Motor Octane No. 90% Sat.
Total Vehicles	**PR**	255	88.2±0.5	94.1±0.7	88.2±0.5	94.1±0.7	88.2±0.5	94.1±0.7
	FBRU	262	85.7±0.5	90.9±0.6	89.8±0.6	96.0±0.8	81.7±0.4	85.8±0.5
	FBRSU	262	85.7±0.5	91.5±0.7	91.1±0.6	97.8±0.8	80.3±0.4	85.1±0.6
	FBRUM	255	84.9±0.5	90.4±0.7	88.2±0.7	95.5±0.9	81.7±0.3	85.3±0.4
Total Cars	**PR**	199	87.6±0.5	92.7±0.7	87.6±0.5	92.7±0.7	87.6±0.5	92.7±0.7
	FBRU	206	85.3±0.5	90.2±0.7	89.2±0.7	95.2±0.9	81.3±0.4	85.2±0.6
	FBRSU	206	85.5±0.6	90.9±0.8	90.8±0.7	97.1±0.9	80.1±0.5	84.6±0.6
	FBRUM	200	84.5±0.6	89.7±0.8	87.6±0.8	94.6±1.0	81.4±0.4	84.9±0.5
Total Trucks and Vans	**PR**	56	89.8±1.4	98.2±1.9	89.8±1.4	98.2±1.9	89.8±1.4	98.2±1.9
	FBRU	56	86.8±1.2	93.9±1.6	91.0±1.4	99.4±1.9	82.5±1.0	88.4±1.3
	FBRSU	56	86.4±1.2	92.6±1.6	92.0±1.3	99.0±1.8	80.7±1.0	86.1±1.4
	FBRUM	55	85.9±1.2	95.6±1.7	89.4±1.6	101.6±2.2	82.3±0.8	89.7±1.1
Total Knock-Sensor Vehicles	**PR**	102	87.0±1.1	93.9±1.4	87.0±1.1	93.9±1.4	87.0±1.1	93.9±1.4
	FBRU	105	84.2±1.0	90.5±1.3	88.0±1.2	95.6±1.6	80.5±0.8	85.5±1.0
	FBRSU	105	83.5±1.1	91.4±1.5	88.6±1.3	97.7±1.8	78.5±0.9	85.1±1.3
	FBRUM	103	83.9±0.7	89.5±1.0	86.8±1.0	94.2±1.3	81.0±0.5	84.7±0.7

TABLE 5

OCTANE NUMBER REQUIREMENTS - 1991 TOTAL VEHICLES

	PR Fuels		FBRU Fuels						FBRSU Fuels					
			(R+M)/2		RON		MON		(R+M)/2		RON		MON	
Percent Satisfied	1991	Diff. 1990	1991	Diff. 1990	1991	Diff. 1990	1991	Diff. 1990	1991	Diff. 1990	1991	Diff. 1990	1991	Diff. 1990
10	82.6	0.8	80.2	-0.3	83.0	-0.3	77.4	-0.2	79.7	-0.7	84.0	-0.6	75.4	-0.9
20	84.9	0.4	82.3	0.1	85.6	0.1	79.0	0.0	81.7	-0.3	86.3	-0.1	77.0	-0.5
30	86.0	0.3	83.7	0.3	87.3	0.5	80.1	0.2	83.2	-0.1	88.2	0.3	78.2	-0.4
40	87.1	0.3	84.7	0.3	88.5	0.4	80.9	0.1	84.7	0.5	90.0	1.0	79.5	0.2
50	88.2	0.2	85.7	0.3	89.8	0.5	81.7	0.2	85.7	0.7	91.1	1.1	80.3	0.3
60	89.3	0.3	86.8	0.6	91.1	0.8	82.5	0.4	86.6	0.7	92.3	1.2	80.9	0.2
70	90.6	0.7	87.5	0.5	92.1	0.8	82.9	0.1	87.5	0.8	93.3	1.2	81.7	0.5
80	91.9	1.1	88.8	0.9	93.6	1.2	84.0	0.5	88.8	1.1	94.8	1.5	82.8	0.7
90	94.1	1.9	90.9	1.7	96.0	2.1	85.8	1.4	91.5	2.4	97.8	2.8	85.1	1.8
95	98.3	4.9	95.5	5.0	101.2	5.7	89.9	4.4	95.8	5.3	102.5	5.9	89.0	4.6

TABLE 6

OCTANE NUMBER REQUIREMENT - 1991 TOTAL VEHICLES
Comparison of FBRUM and FBRU Fuels

Percent	(R+M)/2			RON			MON		
Satisfied	**FBRU**	**FBRUM**	**DIFF.**	**FBRU**	**FBRUM**	**DIFF.**	**FBRU**	**FBRUM**	**DIFF.**
10	80.2	*****	*****	83.0	****	*****	77.4	*****	*****
20	82.3	82.3	0.0	85.6	84.6	-1.0	79.0	80.0	1.0
30	83.7	83.3	-0.4	87.3	86.0	-1.3	80.1	80.6	0.5
40	84.7	84.2	-0.5	88.5	87.1	-1.4	80.9	81.2	0.3
50	85.7	84.9	-0.8	89.8	88.2	-1.6	81.7	81.7	0.0
60	86.8	85.8	-1.0	91.1	89.3	-1.8	82.5	82.3	-0.2
70	87.5	86.9	-0.6	92.1	90.7	-1.4	82.9	83.0	0.1
80	88.8	88.0	-0.8	93.6	92.3	-1.3	84.0	83.7	-0.3
90	90.9	90.4	-0.5	96.0	95.5	-0.5	85.8	85.3	-0.5
95	95.5	96.4	0.9	101.2	102.4	1.2	89.9	90.4	0.5

TABLE 7

OCTANE NUMBER REQUIREMENTS - 1991 TOTAL CARS

	PR Fuels		FBRU Fuels						FBRSU Fuels					
			(R+M)/2		RON		MON		(R+M)/2		RON		MON	
Percent Satisfied	1991	Diff. 1990	1991	Diff. 1990	1991	Diff. 1990	1991	Diff. 1990	1991	Diff. 1990	1991	Diff. 1990	1991	Diff. 1990
10	82.0	0.9	79.9	0.5	82.6	0.6	77.2	0.5	79.6	0.0	83.8	0.2	75.3	-0.4
20	84.5	1.0	82.3	0.5	85.5	0.6	79.0	0.3	81.7	0.1	86.3	0.3	77.0	-0.2
30	85.7	0.6	83.5	0.5	87.0	0.7	79.9	0.3	83.0	0.2	87.9	0.5	78.1	-0.1
40	86.7	0.5	84.4	0.4	88.2	0.6	80.6	0.2	84.4	0.3	89.6	1.0	79.2	0.2
50	87.6	0.3	85.3	0.3	89.2	0.4	81.3	0.1	85.5	0.7	90.8	1.0	80.1	0.2
60	88.6	0.1	86.4	0.3	90.5	0.4	82.2	0.2	86.3	0.5	91.9	0.9	80.7	0.1
70	89.7	0.0	87.3	0.3	91.8	0.5	82.7	-0.1	87.4	0.6	93.1	0.9	81.6	0.3
80	91.0	0.3	88.4	0.4	93.2	0.8	83.7	0.1	88.7	0.9	94.6	1.2	82.7	0.5
90	92.7	0.7	90.2	1.0	95.2	1.2	85.2	0.7	90.9	1.6	97.1	2.0	84.6	1.2
95	94.6	1.3	93.9	3.0	99.4	3.4	88.4	2.5	95.3	4.6	102.0	5.1	88.6	4.0

TABLE 8

OCTANE NUMBER REQUIREMENT - 1991 TOTAL CARS
Comparison of FBRUM and FBRU Fuels

Percent	(R+M)/2			RON			MON		
Satisfied	FBRU	FBRUM	DIFF.	FBRU	FBRUM	DIFF.	FBRU	FBRUM	DIFF.
10	79.9	*****	*****	82.6	****	*****	77.2	*****	*****
20	82.3	81.9	-0.4	85.5	84.1	-1.4	79.0	79.8	0.8
30	83.5	82.9	-0.6	87.0	85.4	-1.6	79.9	80.3	0.4
40	84.4	83.8	-0.6	88.2	86.6	-1.6	80.6	80.9	0.3
50	85.3	84.5	-0.8	89.2	87.6	-1.6	81.3	81.4	0.1
60	86.4	85.3	-1.1	90.5	88.7	-1.8	82.2	81.9	-0.3
70	87.3	86.3	-1.0	91.8	89.9	-1.9	82.7	82.6	-0.1
80	88.4	87.6	-0.8	93.2	91.8	-1.4	83.7	83.5	-0.2
90	90.2	89.7	-0.5	95.2	94.6	-0.6	85.2	84.9	-0.3
95	93.9	93.0	-0.9	99.4	98.6	-0.8	88.4	87.5	-0.9

TABLE 9

OCTANE NUMBER REQUIREMENTS - 1991 TOTAL TRUCKS AND VANS

	PR Fuels		FBRU Fuels						FBRSU					
			(R+M)/2		RON		MON		(R+M)/2		RON		MON	
Percent Satisfied	1991	Diff. 1990	1991	Diff 1990	1991	Diff. 1990	1991	Diff. 1990	1991	Diff. 1990	1991	Diff. 1990	1991	Diff. 1990
10	83.6	-1.0	80.9	-0.9	83.8	-1.2	77.9	-0.8	79.9	-1.4	84.2	-1.5	75.6	-1.4
20	85.6	-0.4	82.6	-0.5	85.9	-0.6	79.2	-0.5	81.6	-1.4	86.3	-1.3	77.0	-1.3
30	86.8	-0.2	84.4	0.2	88.1	0.3	80.6	0.0	84.1	0.1	89.2	0.4	78.9	-0.2
40	88.4	0.3	85.5	0.3	89.6	0.6	81.5	0.2	85.2	0.6	90.5	1.0	79.9	0.2
50	89.8	0.9	86.8	1.0	91.0	1.2	82.5	0.7	86.4	1.1	92.0	1.6	80.7	0.5
60	91.2	1.7	87.2	0.8	91.7	1.2	82.7	0.4	87.0	1.0	92.7	1.5	81.3	0.6
70	92.1	2.0	87.9	0.9	92.6	1.4	83.2	0.4	87.7	1.2	93.6	1.7	81.9	0.8
80	93.6	2.7	89.8	2.0	94.8	2.6	84.9	1.5	89.3	1.9	95.4	2.4	83.3	1.4
90	98.1	5.7	93.9	4.9	99.4	5.7	88.4	4.1	92.6	3.7	99.0	4.3	86.1	3.0
95	****	****	96.7	6.8	102.5	7.7	90.9	5.8	****	****	****	****	****	****

TABLE 10

OCTANE NUMBER REQUIREMENT - 1991 TOTAL TRUCKS AND VANS
Comparison of FBRUM and FBRU Fuels

Percent	(R+M)/2			RON			MON		
Satisfied	FBRU	FBRUM	DIFF.	FBRU	FBRUM	DIFF.	FBRU	FBRUM	DIFF.
10	80.9	82.1	1.2	83.8	84.3	0.5	77.9	79.8	1.9
20	82.6	83.1	0.5	85.9	85.7	-0.2	79.2	80.4	1.2
30	84.4	84.1	-0.3	88.1	87.1	-1.0	80.6	81.1	0.5
40	85.5	85.0	-0.5	89.6	88.2	-1.4	81.5	81.7	0.2
50	86.8	85.9	-0.9	91.0	89.4	-1.6	82.5	82.3	-0.2
60	87.2	86.8	-0.4	91.7	90.7	-1.0	82.7	82.9	0.2
70	87.9	87.5	-0.4	92.6	91.6	-1.0	83.2	83.4	0.2
80	89.8	88.5	-1.3	94.8	93.0	-1.8	84.9	84.1	-0.8
90	93.9	95.6	1.7	99.4	101.5	2.1	88.4	89.7	1.3
95	96.7	97.9	1.2	102.5	104.1	1.6	90.9	91.6	0.7

TABLE 11

OCTANE NUMBER REQUIREMENTS - 1991 TOTAL KNOCK-SENSOR VEHICLES

	PR Fuels		FBRU Fuels						FBRSU Fuels					
			(R+M)/2		RON		MON		(R+M)/2		RON		MON	
Percent Satisfied	1991	Diff. 1990	1991	Diff. 1990	1991	Diff. 1990	1991	Diff. 1990	1991	Diff. 1990	1991	Diff. 1990	1991	Diff. 1990
10	80.4	0.2	79.0	-0.3	81.6	-0.4	76.5	-0.2	78.5	-0.8	82.6	-0.6	74.5	-0.9
20	82.4	-0.7	80.6	-1.5	83.4	-1.9	77.7	-1.2	80.0	-1.8	84.4	-1.8	75.7	-1.7
30	84.5	-0.9	81.7	-1.7	84.9	-2.0	78.6	-1.4	81.0	-2.2	85.5	-2.4	76.5	-2.0
40	85.7	-1.1	82.9	-1.6	86.4	-1.8	79.5	-1.3	82.1	-2.0	86.8	-2.1	77.3	-2.0
50	87.0	-1.1	84.2	-1.3	87.9	-1.6	80.5	-1.1	83.5	-1.5	88.6	-1.4	78.5	-1.5
60	88.6	-0.4	85.7	-0.6	89.7	-0.8	81.6	-0.6	85.5	-0.5	90.8	-0.4	80.1	-0.6
70	90.2	0.4	87.3	0.2	91.8	0.5	82.7	-0.1	86.6	0.0	92.3	0.3	81.0	-0.2
80	91.9	1.2	88.5	0.6	93.3	1.0	83.8	0.3	88.2	0.6	94.2	1.0	82.3	0.3
90	93.9	1.7	90.5	0.8	95.6	1.1	85.5	0.6	91.4	1.9	97.7	2.3	85.1	1.5
95	97.2	3.8	93.8	3.2	99.3	3.7	88.3	2.6	94.7	3.9	101.3	4.4	88.0	3.3
98	****	****	96.5	4.3	102.3	4.8	90.8	3.8	****	****	****	****	****	****

TABLE 12

OCTANE NUMBER REQUIREMENT - 1991 TOTAL KNOCK-SENSOR VEHICLES
Comparison of FBRUM and FBRU Fuels

Percent	(R+M)/2			RON			MON		
Satisfied	FBRU	FBRUM	DIFF.	FBRU	FBRUM	DIFF.	FBRU	FBRUM	DIFF.
10	79.0	****	****	81.6	****	****	76.5	****	****
20	80.6	****	****	83.4	****	****	77.7	****	****
30	81.7	82.1	0.4	84.9	84.4	-0.5	78.6	79.8	1.2
40	82.9	83.0	0.1	86.4	85.6	-0.8	79.5	80.4	0.9
50	84.2	83.9	-0.3	87.9	86.8	-1.1	80.5	81.0	0.5
60	85.7	84.8	-0.9	89.7	87.9	-1.8	81.6	81.6	0.0
70	87.3	86.0	-1.3	91.8	89.6	-2.2	82.7	82.4	-0.3
80	88.5	87.3	-1.2	93.3	91.3	-2.0	83.8	83.3	-0.5
90	90.5	89.5	-1.0	95.6	94.2	-1.4	85.5	84.7	-0.8
95	93.8	95.8	2.0	99.3	101.7	2.4	88.3	89.9	1.6
98	96.5	98.1	1.6	102.3	104.3	2.0	90.8	91.8	1.0

TABLE 13

OCTANE NUMBER REQUIREMENTS - 1991 SELECT MODELS

Select Model : A

Percent Satisfied	PR ON	FBRU RON	FBRU MON	FBRU (R+M)/2	FBRSU RON	FBRSU MON	FBRSU (R+M)/2	FBRUM RON	FBRUM MON	FBRUM (R+M)/2
5	84.3	84.1	78.1	81.1	86.6	77.0	81.8	81.5	78.4	79.9
10	85.1	85.4	78.9	82.1	87.8	77.9	82.8	82.9	79.1	81.0
20	86.1	86.9	79.8	83.3	89.3	79.0	84.1	84.6	79.9	82.2
30	86.8	88.0	80.5	84.2	90.4	79.7	85.0	85.8	80.5	83.2
40	87.4	88.9	81.1	85.0	91.3	80.4	85.8	86.8	81.0	83.9
50	88.0	89.8	81.6	85.7	92.1	81.0	86.6	87.8	81.5	84.7
60	88.6	90.6	82.2	86.4	93.0	81.6	87.3	88.8	82.0	85.4
70	89.2	91.6	82.7	87.2	93.9	82.3	88.1	89.8	82.5	86.2
80	89.9	92.7	83.4	88.0	95.0	83.1	89.0	91.1	83.1	87.1
90	90.9	94.2	84.4	89.3	96.5	84.2	90.3	92.8	83.9	88.4
95	91.7	95.4	85.2	90.3	97.7	85.0	91.4	94.2	84.6	89.4
N	11	11	11	11	11	11	11	11	11	11
Mean	88.0	89.8	81.6	85.7	92.1	81.0	86.6	87.8	81.5	84.7
Estimated Std. Dev. of the Sample Population	2.2	3.4	2.2	2.8	3.4	2.4	2.9	3.9	1.9	2.9
t	2.23	2.23	2.23	2.23	2.23	2.23	2.23	2.23	2.23	2.23
95% Confidence Limits:										
@ 50% Satisfied	1.5	2.3	1.4	1.9	2.3	1.6	2.0	2.6	1.3	1.9
@ 90% Satisfied	2.1	3.2	2.0	2.6	3.1	2.3	2.7	3.6	1.8	2.7

SPEED RANGE FOR MAXIMUM OCTANE NUMBER REQUIREMENTS

SPEED RANGE	PR	FBRU	FBRSU	FBRUM
1599 and Lower	34	0	0	11
1600 - 1999	11	11	0	11
2000 - 2399	11	11	0	11
2400 - 2799	11	33	56	11
2800 - 3199	0	0	0	11
3200 and Higher	33	45	44	45

% Select Model Knocking on Tank Fuel = 66.7
Number of Test Vehicles = 11
Vehicles rated on Tank Fuel = 3

TABLE 14

OCTANE NUMBER REQUIREMENTS - 1991 SELECT MODELS

Select Model : B

Percent Satisfied	PR ON	FBRU RON	FBRU MON	FBRU (R+M)/2	FBRSU RON	FBRSU MON	FBRSU (R+M)/2	FBRUM RON	FBRUM MON	FBRUM (R+M)/2
5	87.3	87.0	79.4	83.2	88.2	77.7	83.0	83.8	78.6	81.2
10	88.3	89.0	80.8	84.9	90.0	79.2	84.6	86.4	80.2	83.3
20	89.5	91.3	82.6	87.0	92.3	80.9	86.6	89.5	82.2	85.9
30	90.3	93.0	83.8	88.4	93.9	82.2	88.0	91.8	83.6	87.7
40	91.0	94.5	84.9	89.7	95.2	83.2	89.2	93.7	84.9	89.3
50	91.7	95.9	85.9	90.9	96.5	84.2	90.4	95.5	86.0	90.8
60	92.4	97.2	86.9	92.1	97.8	85.2	91.5	97.4	87.2	92.3
70	93.1	98.7	88.0	93.4	99.1	86.3	92.7	99.3	88.4	93.8
80	94.0	100.4	89.3	94.8	100.7	87.6	94.1	101.6	89.8	95.7
90	95.2	102.8	91.1	96.9	103.0	89.3	96.1	104.7	91.8	98.3
95	96.1	104.7	92.5	98.6	104.8	90.7	97.8	107.3	93.5	100.4
N	11	11	11	11	11	11	11	11	11	11
Mean	91.7	95.9	85.9	90.9	96.5	84.2	90.4	95.5	86.0	90.8
Estimated Std. Dev. of the Sample Population	2.7	5.4	4.0	4.7	5.0	3.9	4.5	7.1	4.5	5.8
t	2.23	2.23	2.23	2.23	2.23	2.23	2.23	2.23	2.23	2.23
95% Confidence Limits:										
@ 50% Satisfied	1.8	3.6	2.7	3.2	3.4	2.6	3.0	4.8	3.1	3.9
@ 90% Satisfied	2.5	5.0	3.7	4.3	4.7	3.7	4.2	6.6	4.2	5.4

SPEED RANGE FOR MAXIMUM OCTANE NUMBER REQUIREMENTS

SPEED RANGE	PR	FBRU	FBRSU	FBRUM
1599 and Lower	27	30	30	30
1600 - 1999	37	20	10	30
2000 - 2399	0	10	0	0
2400 - 2799	9	0	0	20
2800 - 3199	18	20	40	0
3200 and Higher	9	20	20	20

% Select Model Knocking on Tank Fuel = 100.0
Number of Test Vehicles = 11
Vehicles rated on Tank Fuel = 2

TABLE 15

OCTANE NUMBER REQUIREMENTS - 1991 SELECT MODELS

Select Model : C

Percent Satisfied	PR ON	FBRU RON	FBRU MON	FBRU (R+M)/2	FBRSU RON	FBRSU MON	FBRSU (R+M)/2	FBRUM RON	FBRUM MON	FBRUM (R+M)/2
5	81.6	81.8	76.3	79.1	81.4	73.4	77.4	80.9	77.5	79.2
10	83.5	83.9	77.7	80.8	83.7	75.1	79.4	83.0	78.7	80.9
20	85.9	86.4	79.4	82.9	86.4	77.0	81.7	85.6	80.2	82.9
30	87.6	88.2	80.6	84.4	88.4	78.4	83.4	87.4	81.3	84.4
40	89.0	89.7	81.7	85.7	90.1	79.6	84.8	89.0	82.2	85.6
50	90.4	91.1	82.6	86.9	91.6	80.7	86.2	90.5	83.0	86.8
60	91.7	92.6	83.6	88.1	93.2	81.9	87.5	92.0	83.9	87.9
70	93.2	94.1	[illegible]	89.4	94.9	83.1	89.0	93.6	84.8	89.2
80	94.9	95.9	85.9	90.9	96.9	84.5	90.7	95.4	85.9	90.6
90	97.2	98.4	87.6	93.0	99.6	86.4	93.0	98.0	87.4	92.7
95	99.2	100.5	89.0	94.7	101.9	88.0	94.9	100.1	88.6	94.3
N	14	14	14	14	14	14	14	14	14	14
Mean	90.4	91.1	82.6	86.9	91.6	80.7	86.2	90.5	83.0	86.8
Estimated Std. Dev. of the Sample Population	5.3	5.7	3.8	4.7	6.2	4.4	5.3	5.8	3.4	4.6
t	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16
95% Confidence Limits:										
@ 50% Satisfied	3.1	3.3	2.2	2.7	3.6	2.6	3.1	3.4	2.0	2.7
@ 90% Satisfied	4.2	4.5	3.0	3.8	4.9	3.5	4.2	4.6	2.7	3.6

SPEED RANGE FOR MAXIMUM OCTANE NUMBER REQUIREMENTS

SPEED RANGE	PR	FBRU	FBRSU	FBRUM
1599 and Lower	43	21	21	42
1600 - 1999	14	21	21	8
2000 - 2399	36	44	30	42
2400 - 2799	7	14	7	0
2800 - 3199	0	0	14	8
3200 and Higher	0	0	7	0

% Select Model Knocking on Tank Fuel = 50.0
Number of Test Vehicles = 14
Vehicles rated on Tank Fuel = 2

TABLE 16

OCTANE NUMBER REQUIREMENTS - 1991 SELECT MODELS

Select Model : D

Percent Satisfied	PR ON	FBRU RON	FBRU MON	FBRU (R+M)/2	FBRSU RON	FBRSU MON	FBRSU (R+M)/2	FBRUM RON	FBRUM MON	FBRUM (R+M)/2
5	76.3	77.0	73.7	75.3	78.9	72.0	75.4	82.1	78.8	80.5
10	77.8	78.9	74.9	76.9	80.6	73.1	76.8	82.8	79.1	81.0
20	79.6	81.1	76.3	78.7	82.7	74.5	78.6	83.7	79.5	81.6
30	81.0	82.8	77.3	80.1	84.1	75.6	79.8	84.3	79.8	82.0
40	82.1	84.2	78.2	81.2	85.4	76.4	80.9	84.8	80.1	82.4
50	83.1	85.5	79.0	82.3	86.6	77.2	81.9	85.3	80.3	82.8
60	84.2	86.8	79.8	83.3	87.8	78.0	82.9	85.7	80.5	83.1
70	85.3	88.3	80.7	84.5	89.1	78.9	84.0	86.3	80.8	83.5
80	86.7	89.9	81.7	85.8	90.6	79.9	85.3	86.9	81.0	84.0
90	88.5	92.2	83.2	87.7	92.6	81.3	87.0	87.7	81.4	84.6
95	90.0	94.1	84.3	89.2	94.4	82.5	88.4	88.4	81.8	85.1
N	17	18	18	18	18	18	18	17	17	17
Mean	83.1	85.5	79.0	82.3	86.6	77.2	81.9	85.3	80.3	82.8
Estimated Std. Dev. of the Sample Population	4.2	5.2	3.2	4.2	4.7	3.2	4.0	1.9	0.9	1.4
t	2.12	2.11	2.11	2.11	2.11	2.11	2.11	2.12	2.12	2.12
95% Confidence Limits:										
@ 50% Satisfied	2.1	2.6	1.6	2.1	2.3	1.6	2.0	1.0	0.5	0.7
@ 90% Satisfied	2.9	3.5	2.2	2.9	3.2	2.2	2.7	1.3	0.6	1.0

SPEED RANGE FOR MAXIMUM OCTANE NUMBER REQUIREMENTS

SPEED RANGE	PR	FBRU	FBRSU	FBRUM
1599 and Lower	19	6	6	10
1600 - 1999	49	34	33	70
2000 - 2399	6	18	28	0
2400 - 2799	13	12	11	10
2800 - 3199	13	24	22	10
3200 and Higher	0	6	0	0

% Select Model Knocking on Tank Fuel = 0.0
Number of Test Vehicles = 18
Vehicles rated on Tank Fuel = 1

TABLE 17

OWNER/RATER COMPARISON OF TANK FUEL KNOCK

(1984-1991 CRC Octane Number Requirement Surveys)

Model Year:	1991	1990	1989	1988	1987	1986	1985	1984
Fuel:	Unleaded	Unleaded	Unleaded	Unleaded	Unleaded	Unleaded	Unleaded	Unleaded
Total Reports:	55	101	124	155	179	160	143	149
Percent Knocking								
Trained Rater	43.6	21.8	30.6	39.4	39.7	33.1	37.8	51.7
Owner	12.7	4.0	7.3	15.5	24.0	16.3	18.9	26.2
Owner/Rater Ratio	0.29	0.18	0.24	0.39	0.61	0.49	0.50	0.51
Percent Owners Objecting								
Based on:								
Total Reports	3.6	1.0	0.8	0.6	2.8	2.5	9.8	7.4
Owners Reporting Knock	28.6	25.0	11.1	4.2	11.6	15.4	51.9	28.2

TABLE 18

TANK-FUEL KNOCK REPORTED BY TRAINED OBSERVERS

Model Year	No. Survey	Total Vehicles Tested on Tank Fuel: No. Tested	Total Vehicles Tested on Tank Fuel: % Knocking (Wtg. Avg.)
1991	262	55	47
1990	356	103	18
1989	391	265	30
1988	391	293	31
1987	389	322	35
1986	377	330	31
1985	374	327	37
1984	407	358	49

TABLE 19

ENGINE SPEEDS FOR OCTANE NUMBER REQUIREMENTS

Weighted % of Vehicles Having Requirements
in Indicated (rpm) Ranges

All 1991 Vehicles

Engine Speed Range	PR Fuels	FBRU Fuels	FBRSU Fuels	FBRUM Fuels
1599 and Lower	16.3	11.3	10.6	13.9
1600 - 1999	15.9	19.3	15.9	19.2
2000 - 2399	25.6	23.7	23.0	24.9
2400 - 2799	25.3	24.4	17.4	22.3
2800 - 3199	8.2	8.4	15.8	10.2
3200 - 3599	3.7	4.8	5.9	2.8
3600 and Higher	5.0	8.1	11.4	6.7

TABLE 20

THROTTLE/GEAR POSITION FOR 1991

FBRU OCTANE NUMBER REQUIREMENTS

Throttle Position	Transmission Type & Gear		No. of Vehicles*	% of Vehicles
	Automatic Transmission			
Maximum	4-Speed:	4th	36	14
		3rd	38	15
		2nd	34	13
	3-Speed:	3rd	28	11
		2nd	13	5
Part	4-Speed:	4th	28	11
		3rd	18	7
		2nd	4	2
	3-Speed	3rd	18	7
		2nd	0	0
	Manual Transmission			
Maximum	5-Speed:	4th	13	5
		3rd	7	3
	4-Speed:	3rd	0	0
Part	6-Speed:	4th	1	<1
	5-Speed:	5th	1	<1
		4th	9	3
		3rd	7	3
	4-Speed:	4th	0	0

* Seven test vehicles not counted, because all FBRU fuels satisfied their octane number requirements.

Figure 1

DISTRIBUTION OF ODOMETER MILEAGE FOR 1991 MODEL VEHICLES TESTED

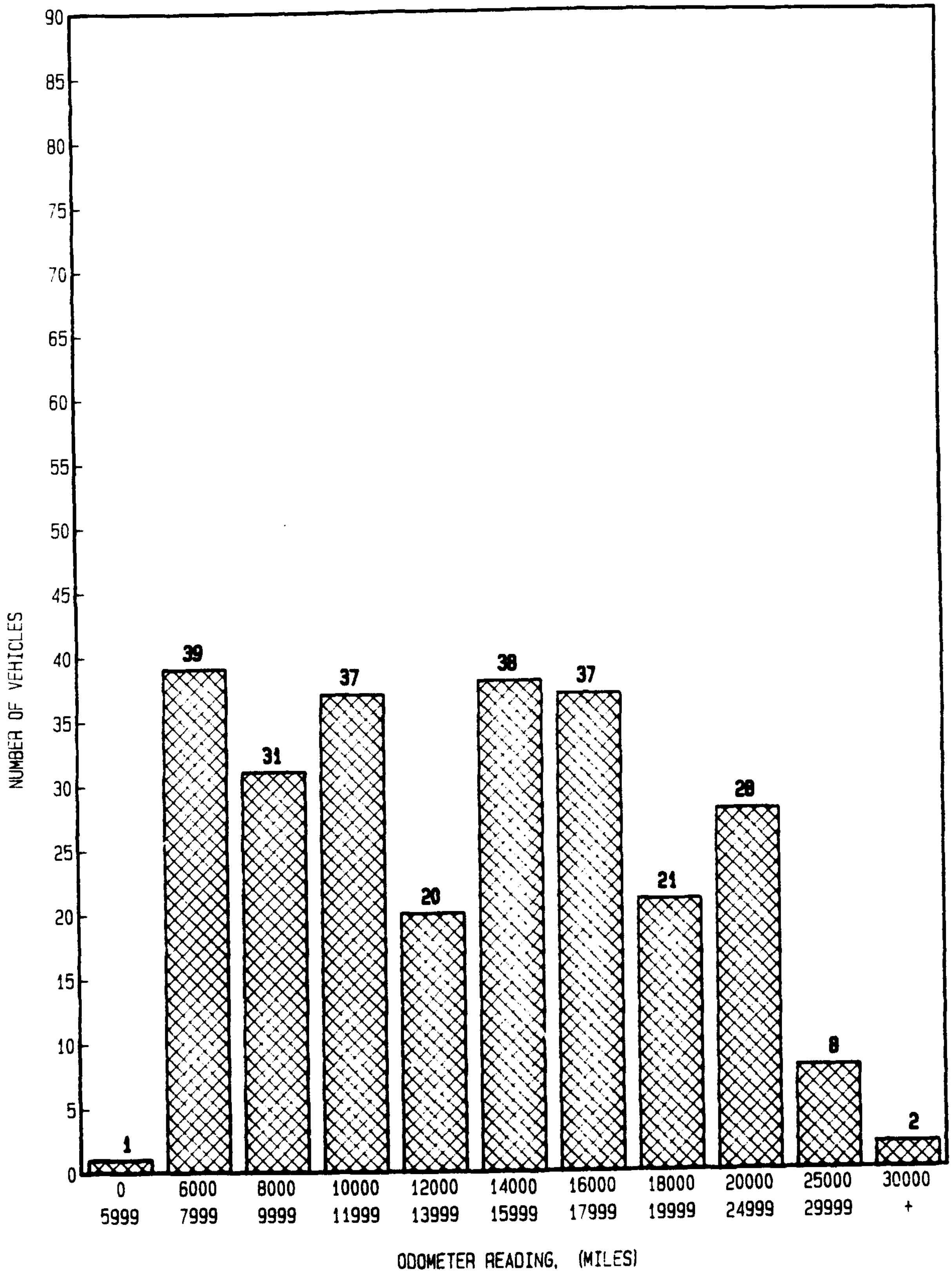


Figure 2

DISTRIBUTION OF MAXIMUM PR FUEL (R+M)/2 OCTANE NUMBER REQUIREMENTS

1991 TOTAL VEHICLES

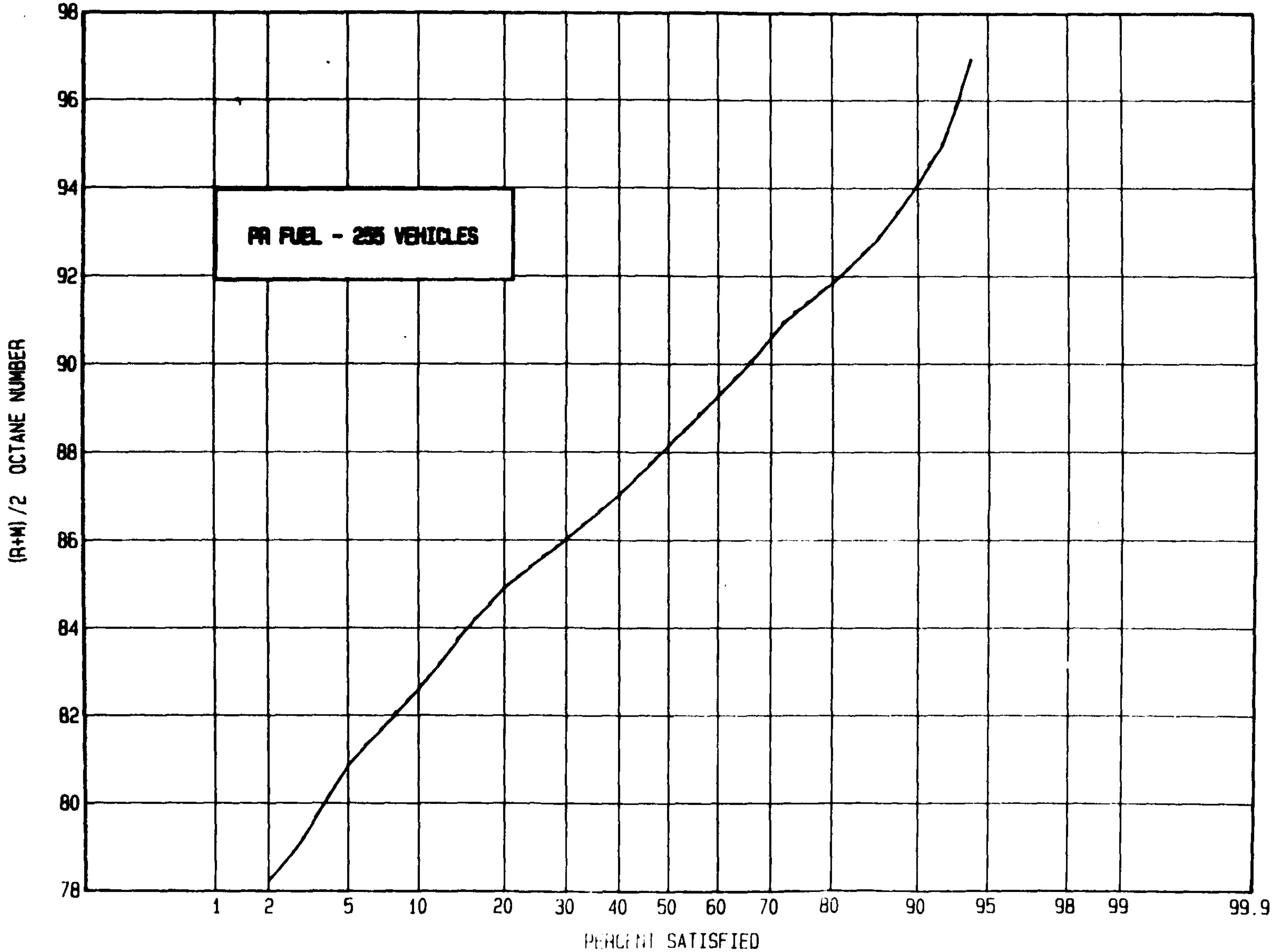


Figure 3
DISTRIBUTION OF MAXIMUM FBRU FUEL (R+M)/2 OCTANE NUMBER REQUIREMENTS
1991 TOTAL VEHICLES

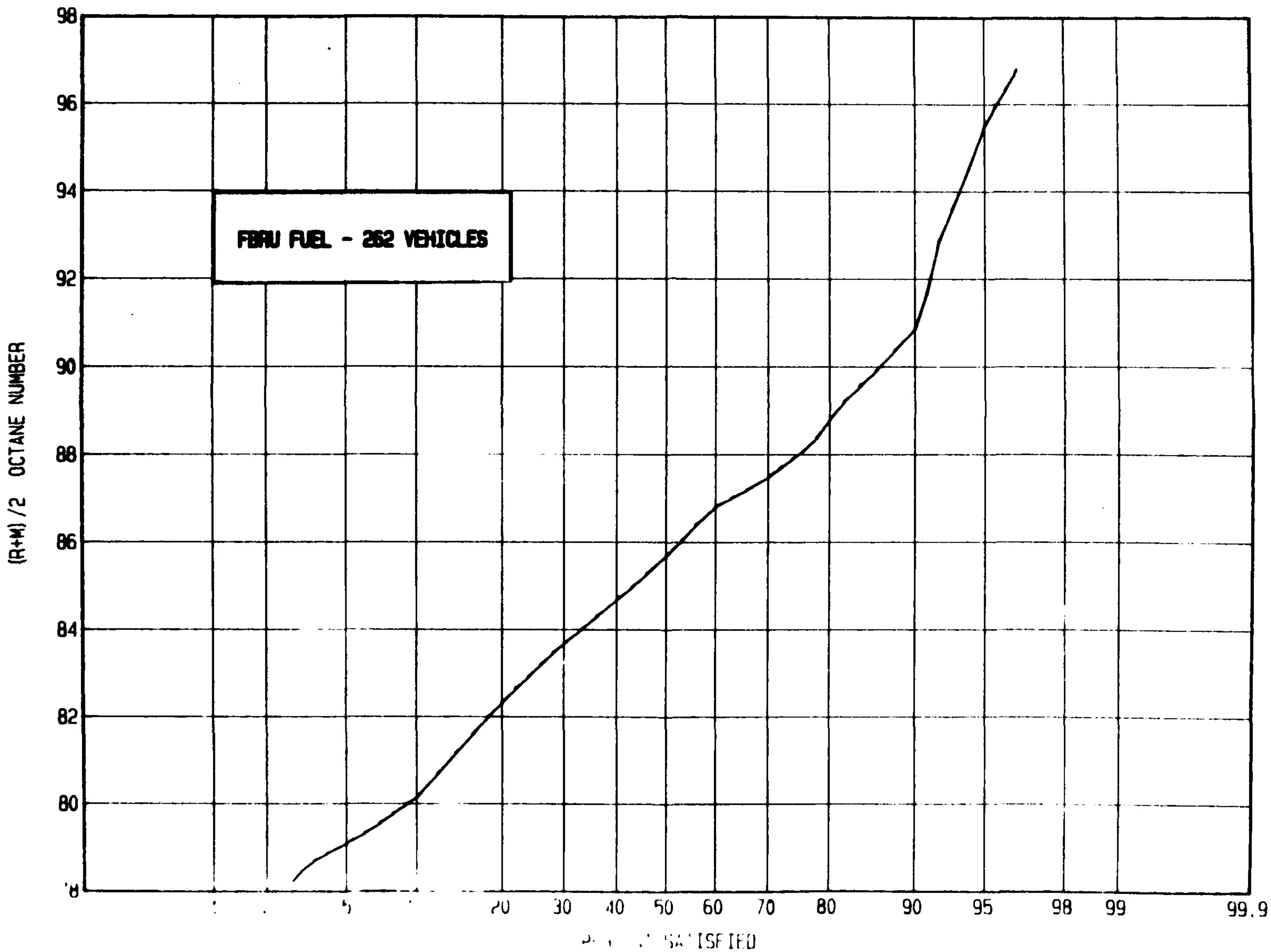


Figure 4
DISTRIBUTION OF MAXIMUM FBRSU FUEL (R+M)/2 OCTANE NUMBER REQUIREMENTS
1991 TOTAL VEHICLES

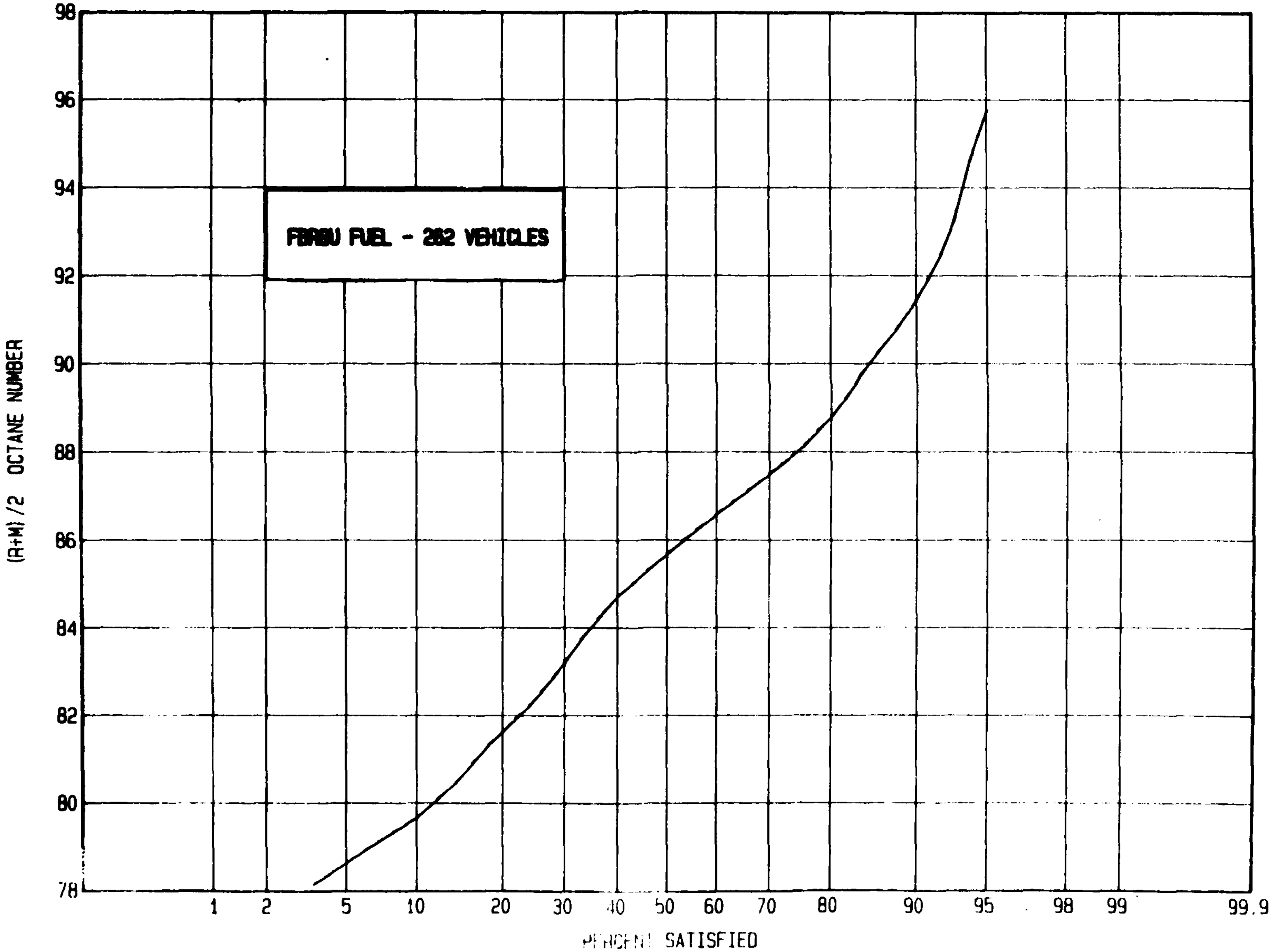


Figure 5

DISTRIBUTION OF MAXIMUM FBRUM FUEL (R+M)/2 OCTANE NUMBER REQUIREMENTS

1991 TOTAL VEHICLES

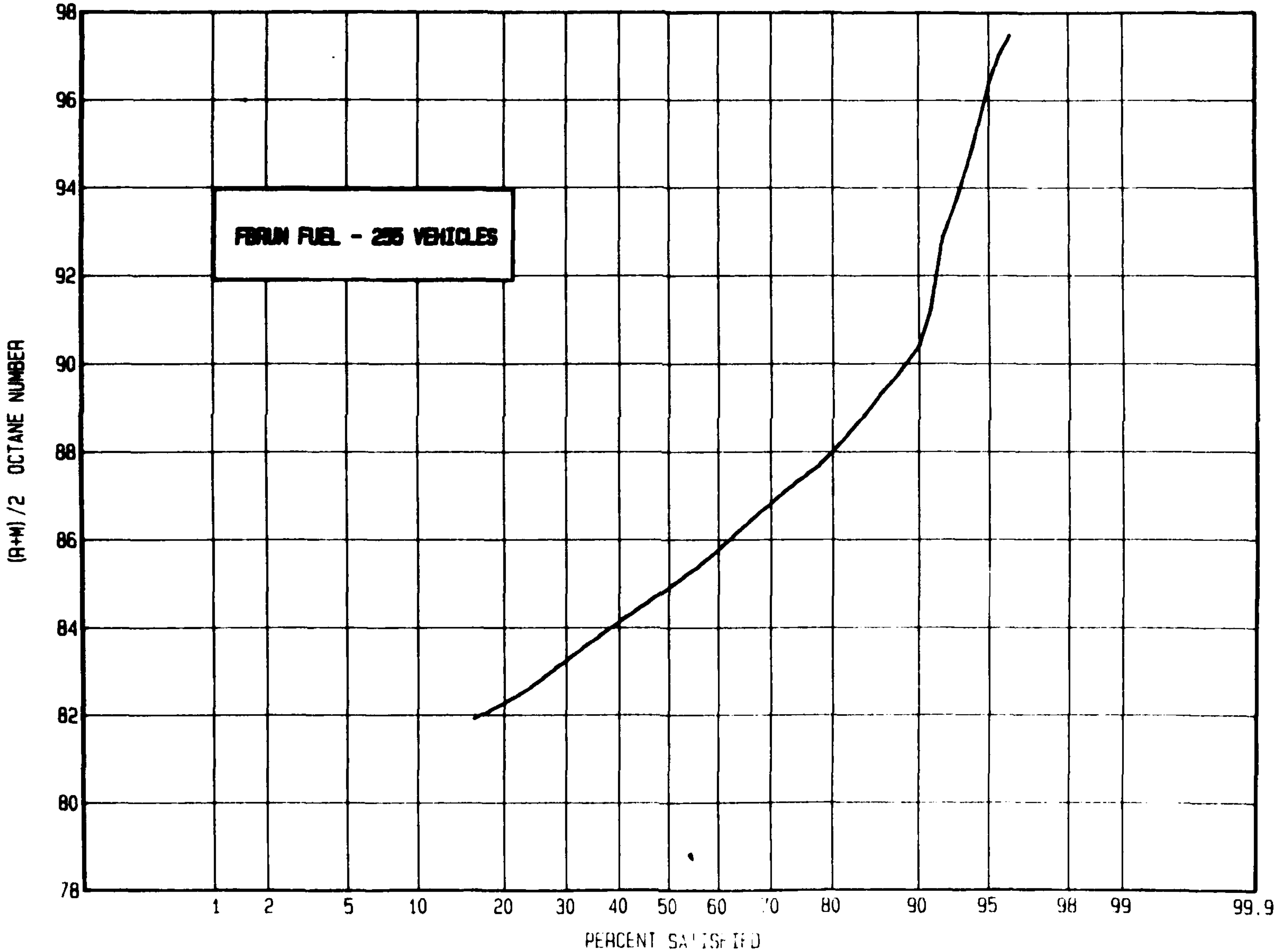


Figure 6
DISTRIBUTION OF MAXIMUM (R+M)/2 OCTANE NUMBER REQUIREMENTS
1991 TOTAL VEHICLES

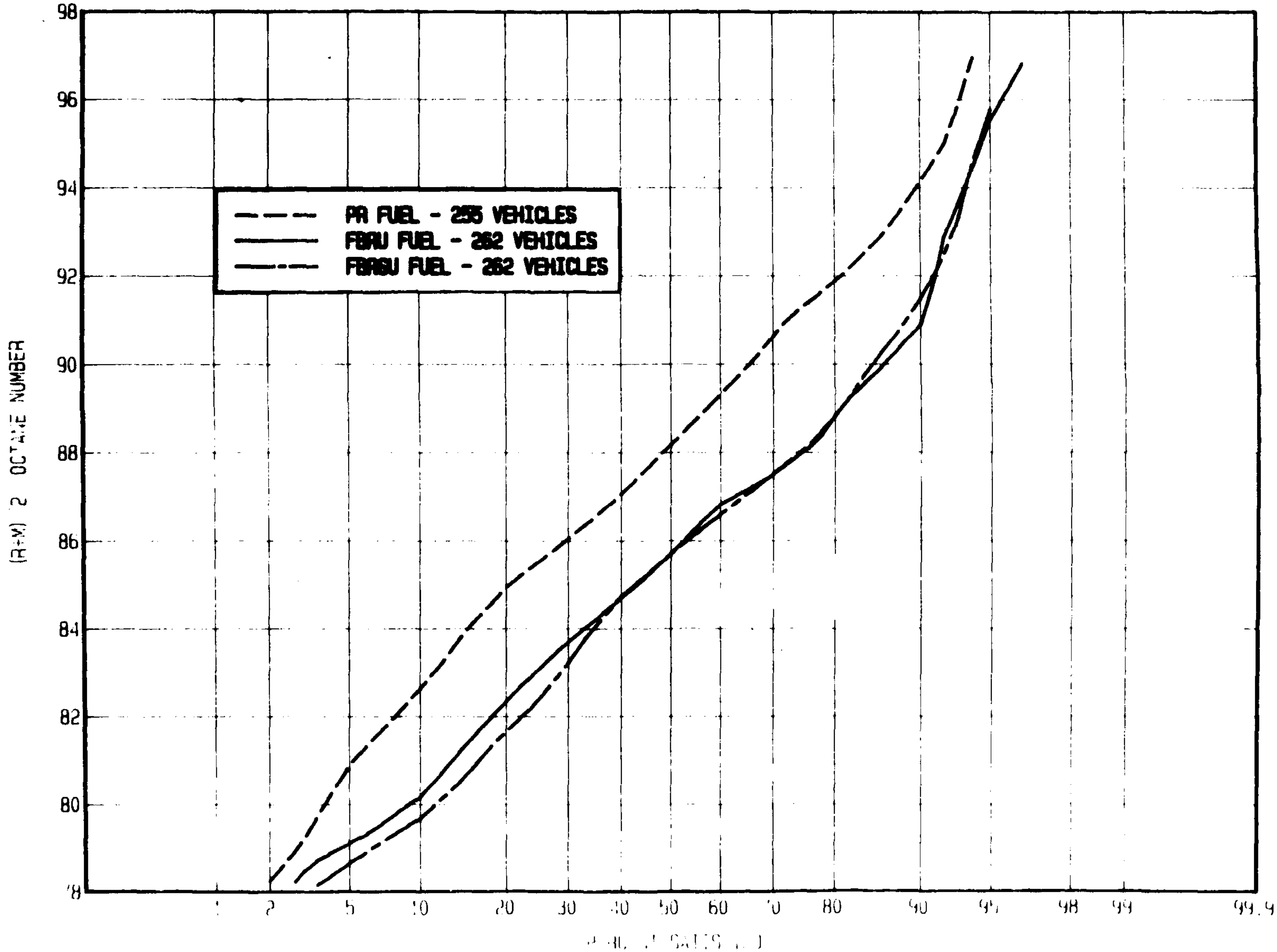


Figure 7
DISTRIBUTION OF MAXIMUM (R+M)/2 OCTANE NUMBER REQUIREMENTS
1991 TOTAL VEHICLES

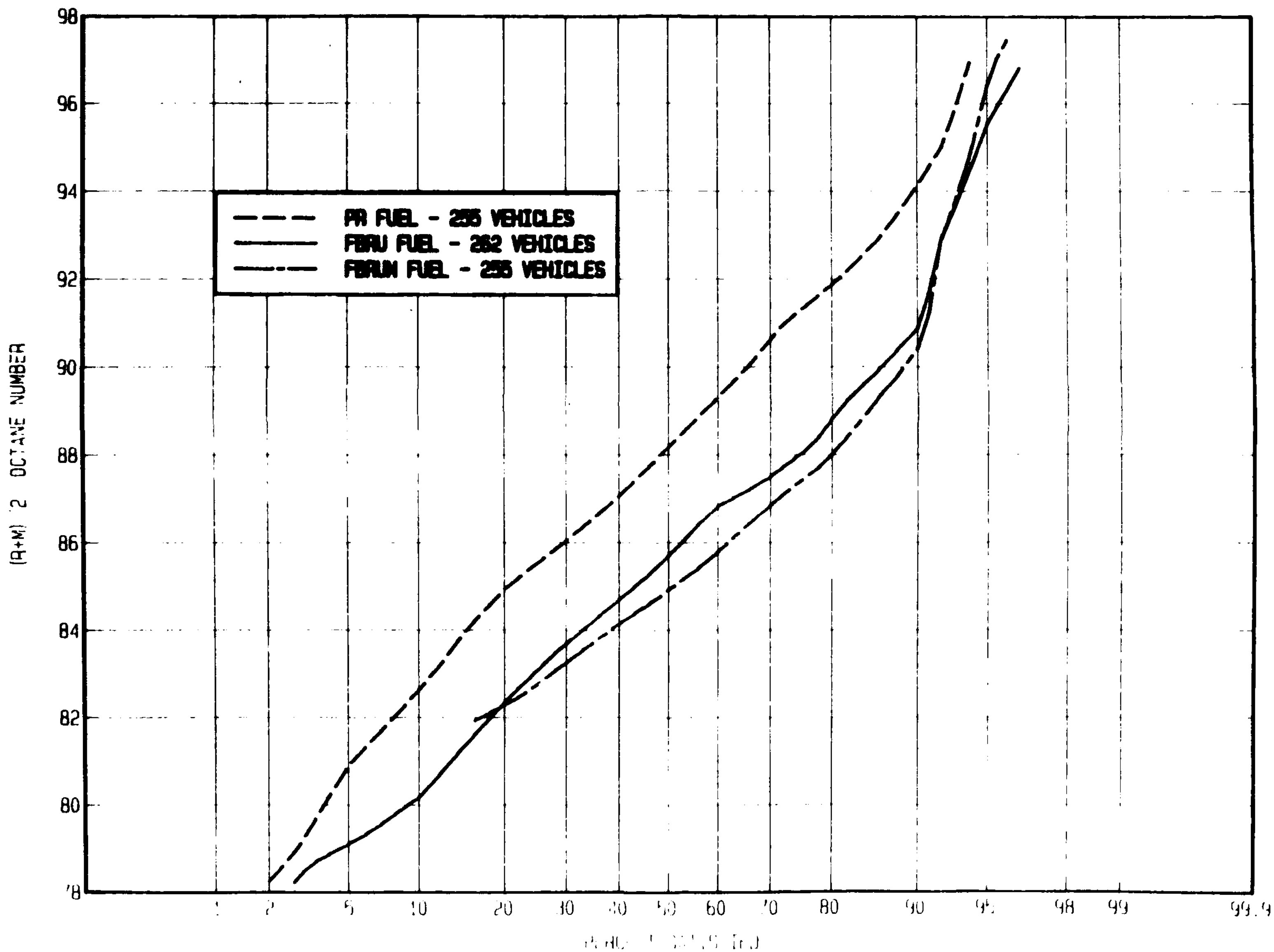


Figure 8

DISTRIBUTION OF MAXIMUM FBRU FUEL (R+M)/2 OCTANE NUMBER REQUIREMENTS
1991 AND 1990 TOTAL VEHICLES

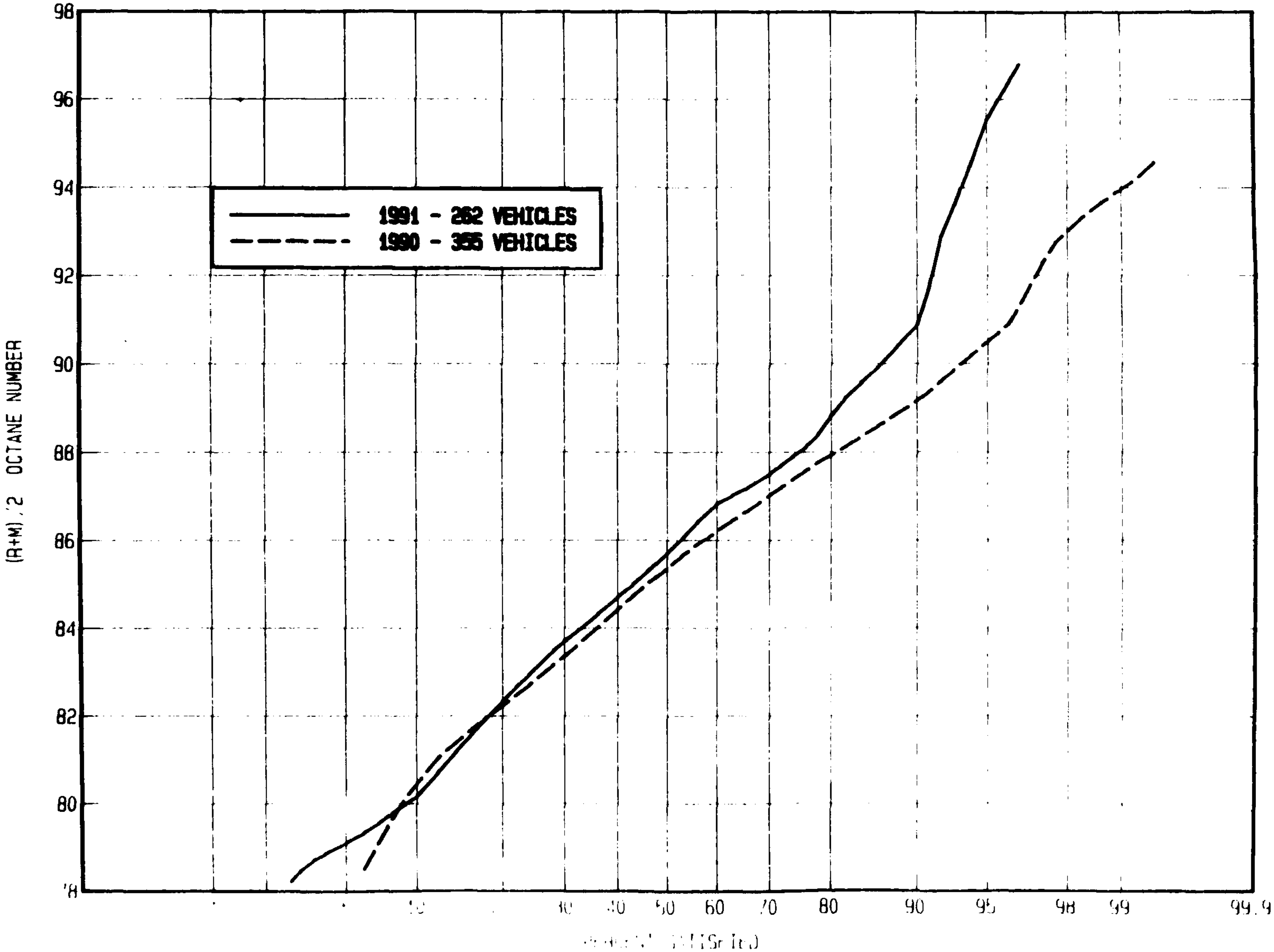


Figure 9
DISTRIBUTION OF MAXIMUM (R+M)/2 OCTANE NUMBER REQUIREMENTS
1991 TOTAL CARS

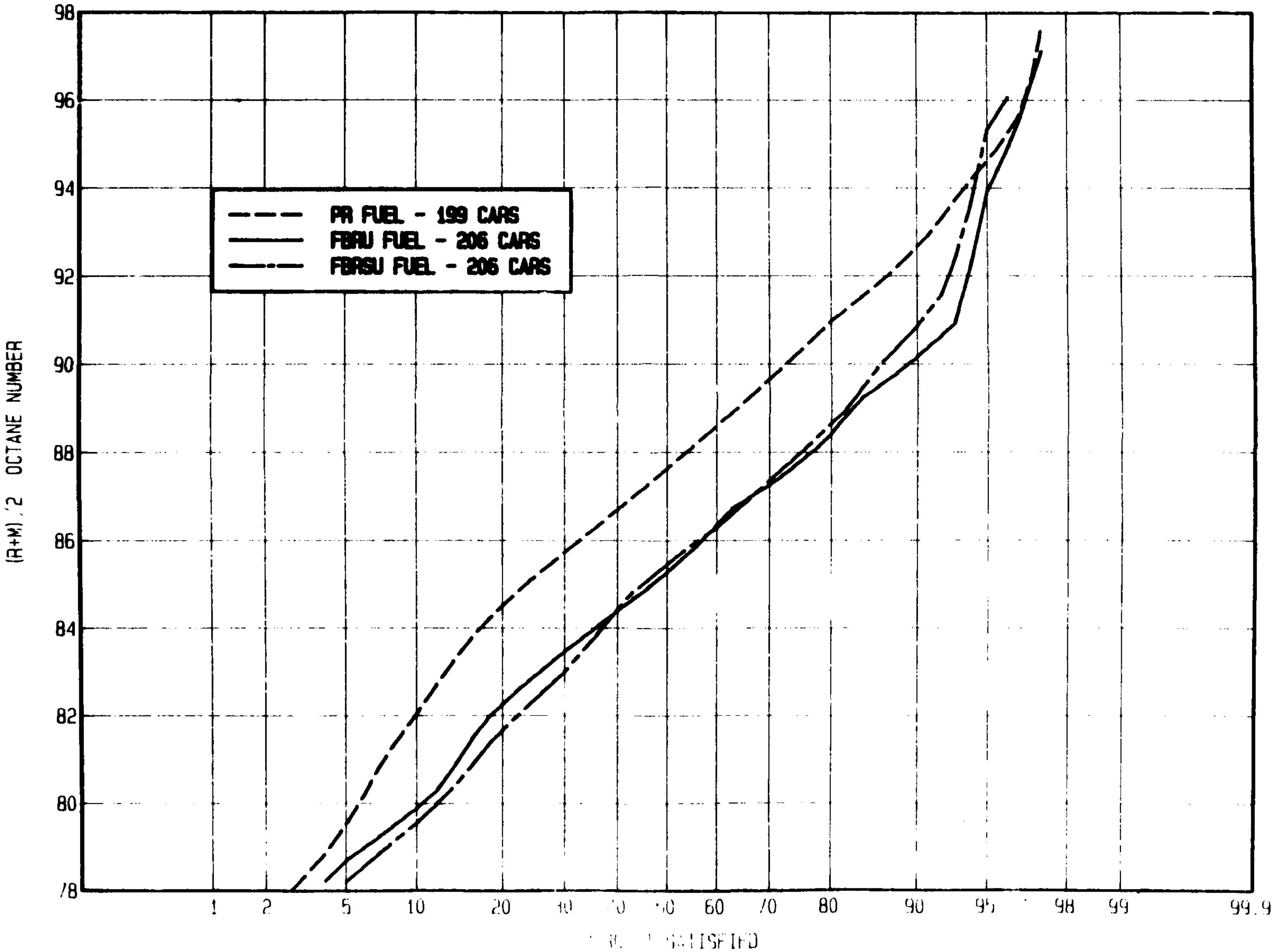


Figure 10
DISTRIBUTION OF MAXIMUM (R+M)/2 OCTANE NUMBER REQUIREMENTS
1991 TOTAL CARS

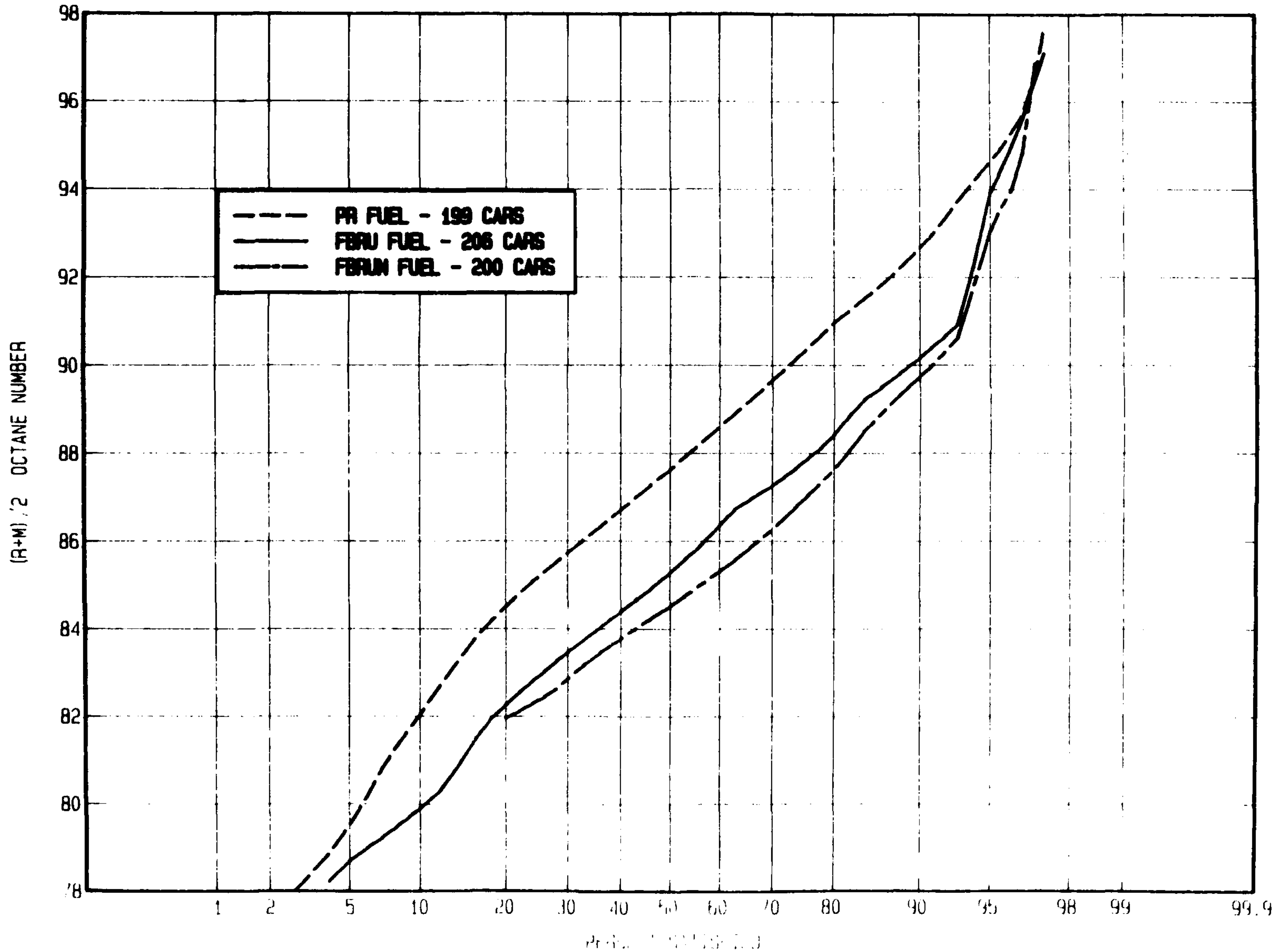


Figure 11
DISTRIBUTION OF MAXIMUM FBRU FUEL (R+M)/2 OCTANE NUMBER REQUIREMENTS
1991 AND 1990 TOTAL CARS

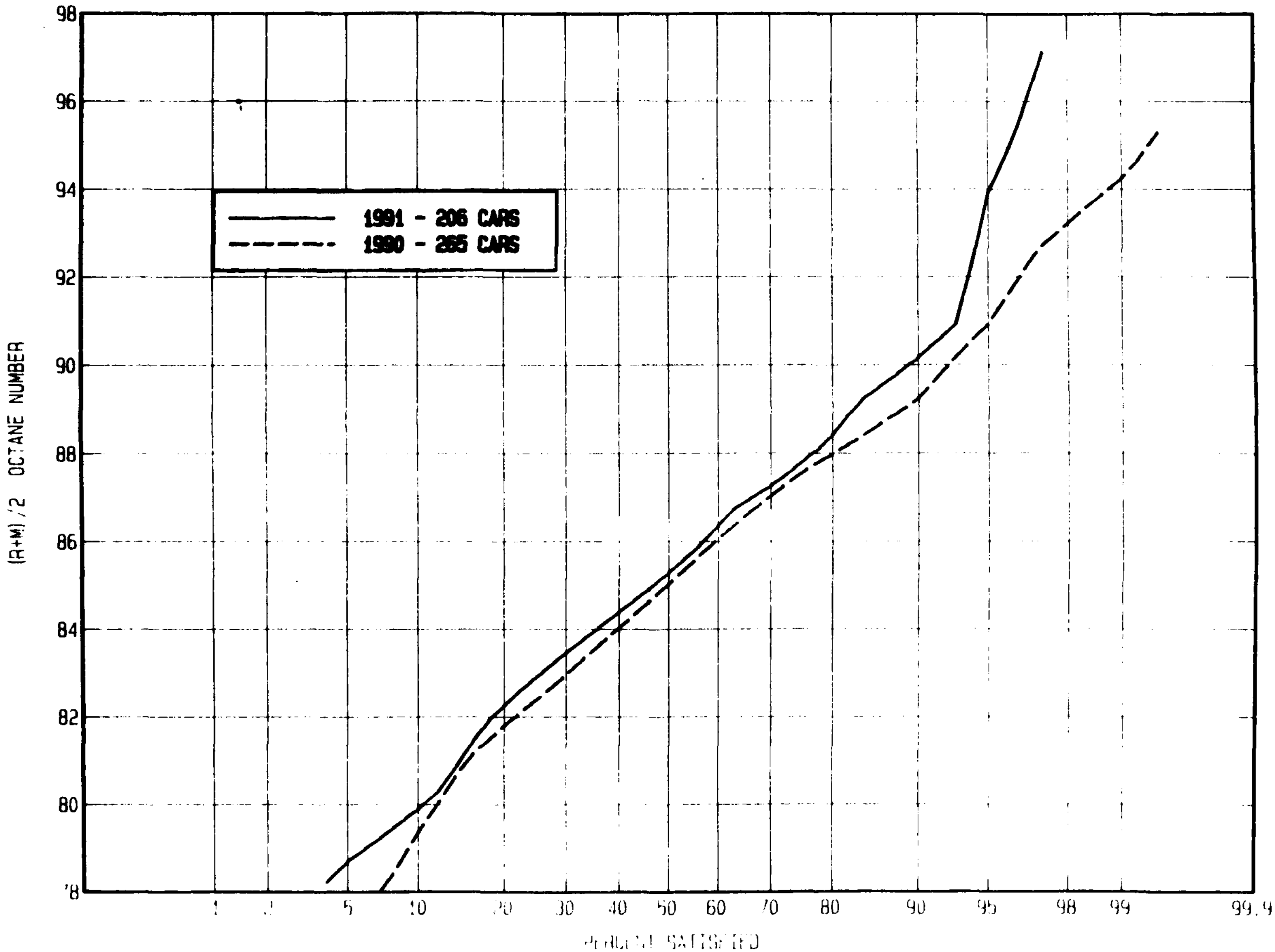


Figure 12

DISTRIBUTION OF MAXIMUM (R+M)/2 OCTANE NUMBER REQUIREMENTS

1991 TOTAL TRUCKS AND VANS

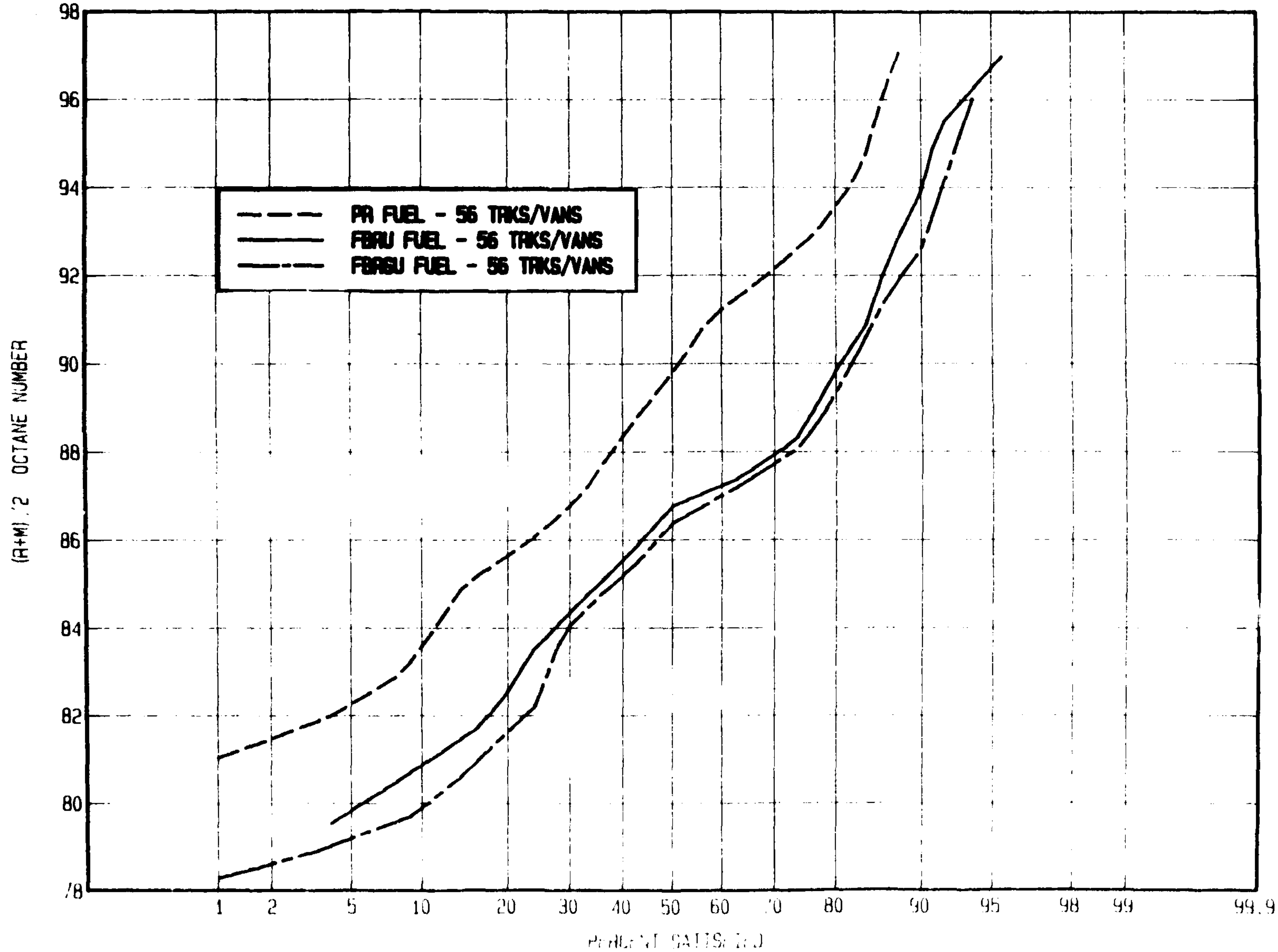


Figure 13
DISTRIBUTION OF MAXIMUM (R+M)/2 OCTANE NUMBER REQUIREMENTS
1991 TOTAL TRUCKS AND VANS

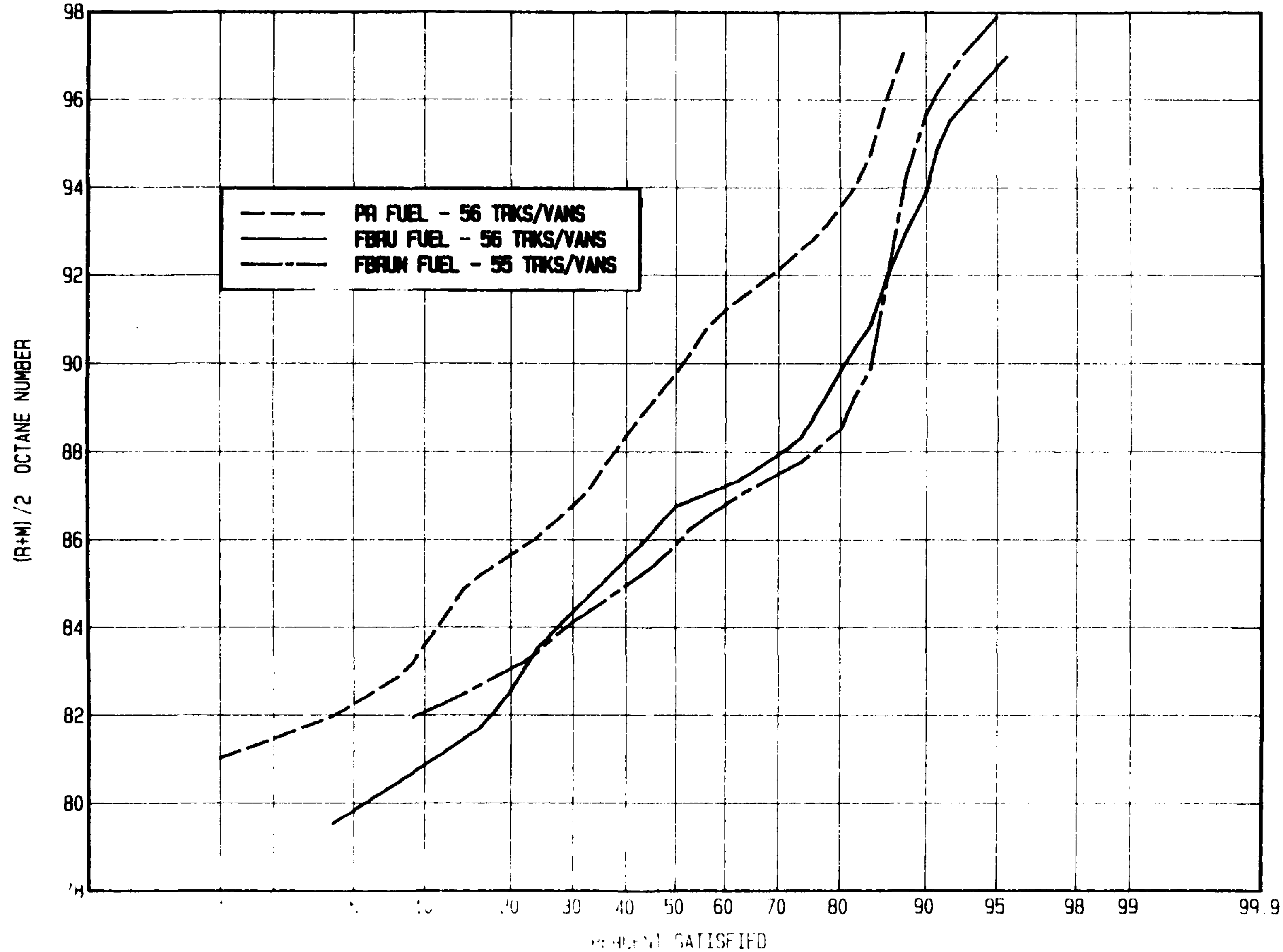


Figure 14

DISTRIBUTION OF MAXIMUM FBRU FUEL (R+M)/2 OCTANE NUMBER REQUIREMENTS

1991 AND 1990 TOTAL TRUCKS AND VANS

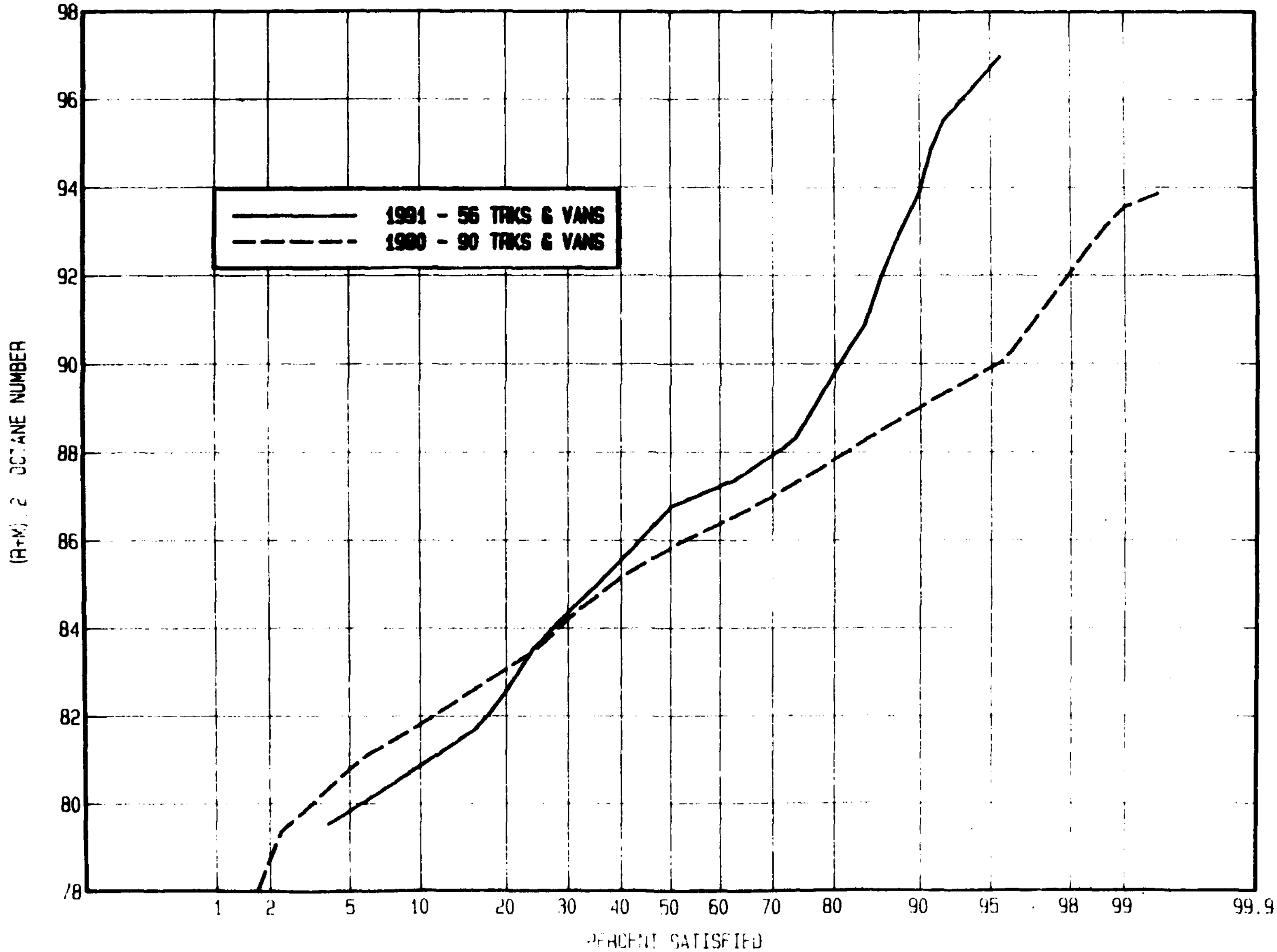


Figure 15

DISTRIBUTION OF MAXIMUM (R+M)/2 OCTANE NUMBER REQUIREMENTS

1991 KNOCK SENSOR VEHICLES

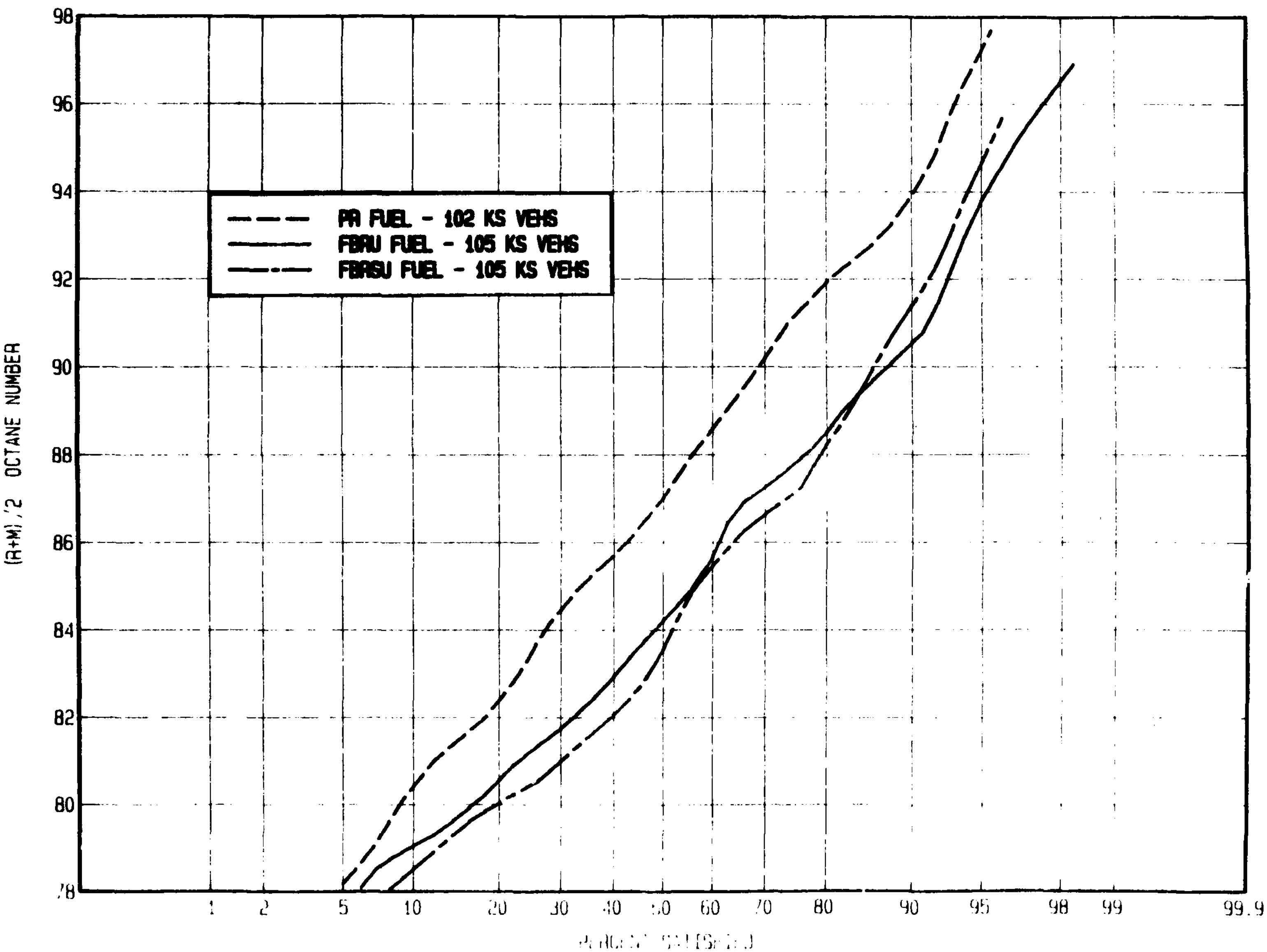


Figure 16

DISTRIBUTION OF MAXIMUM (R+M)/2 OCTANE NUMBER REQUIREMENTS

1991 KNOCK SENSOR VEHICLES

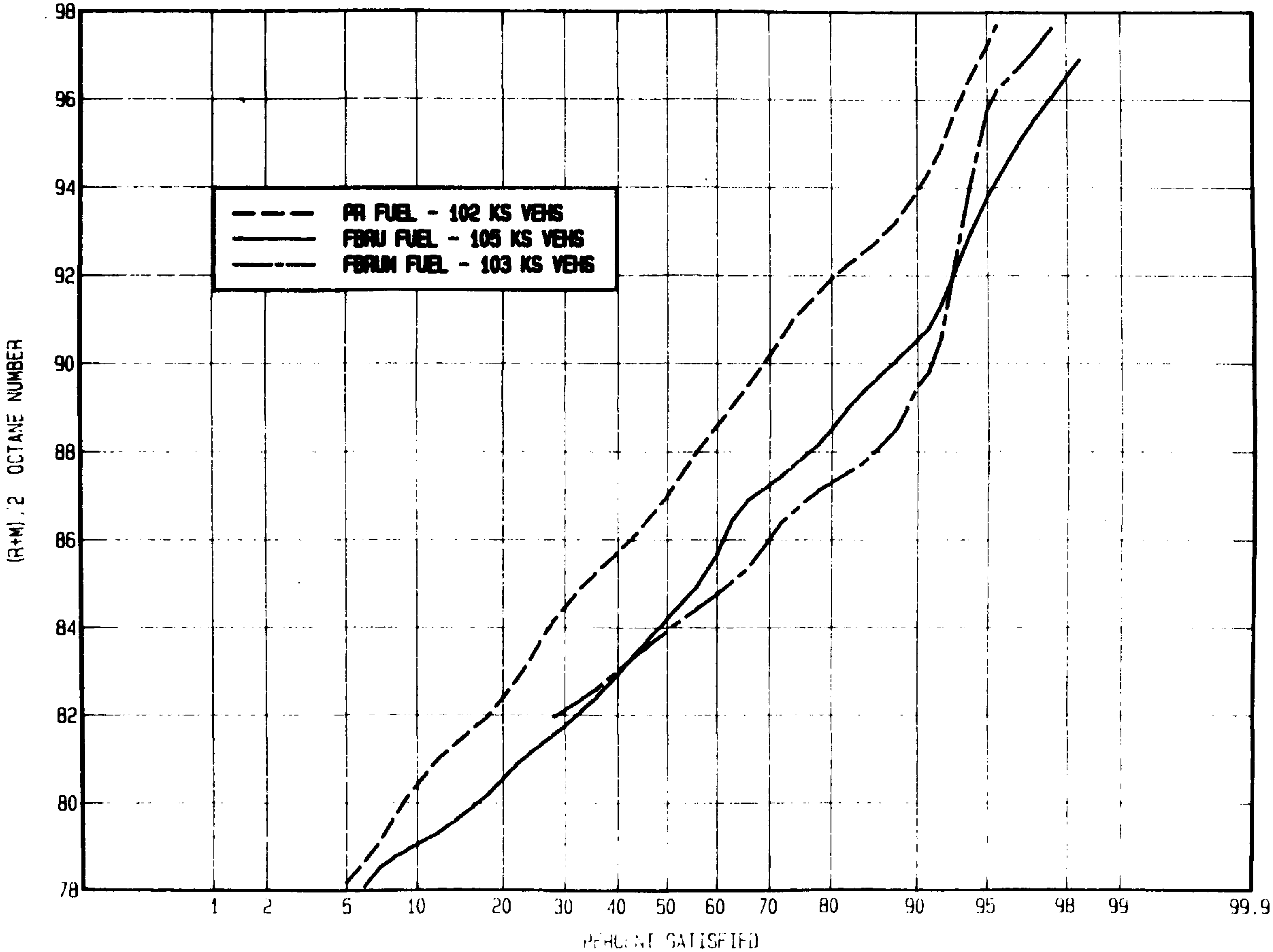
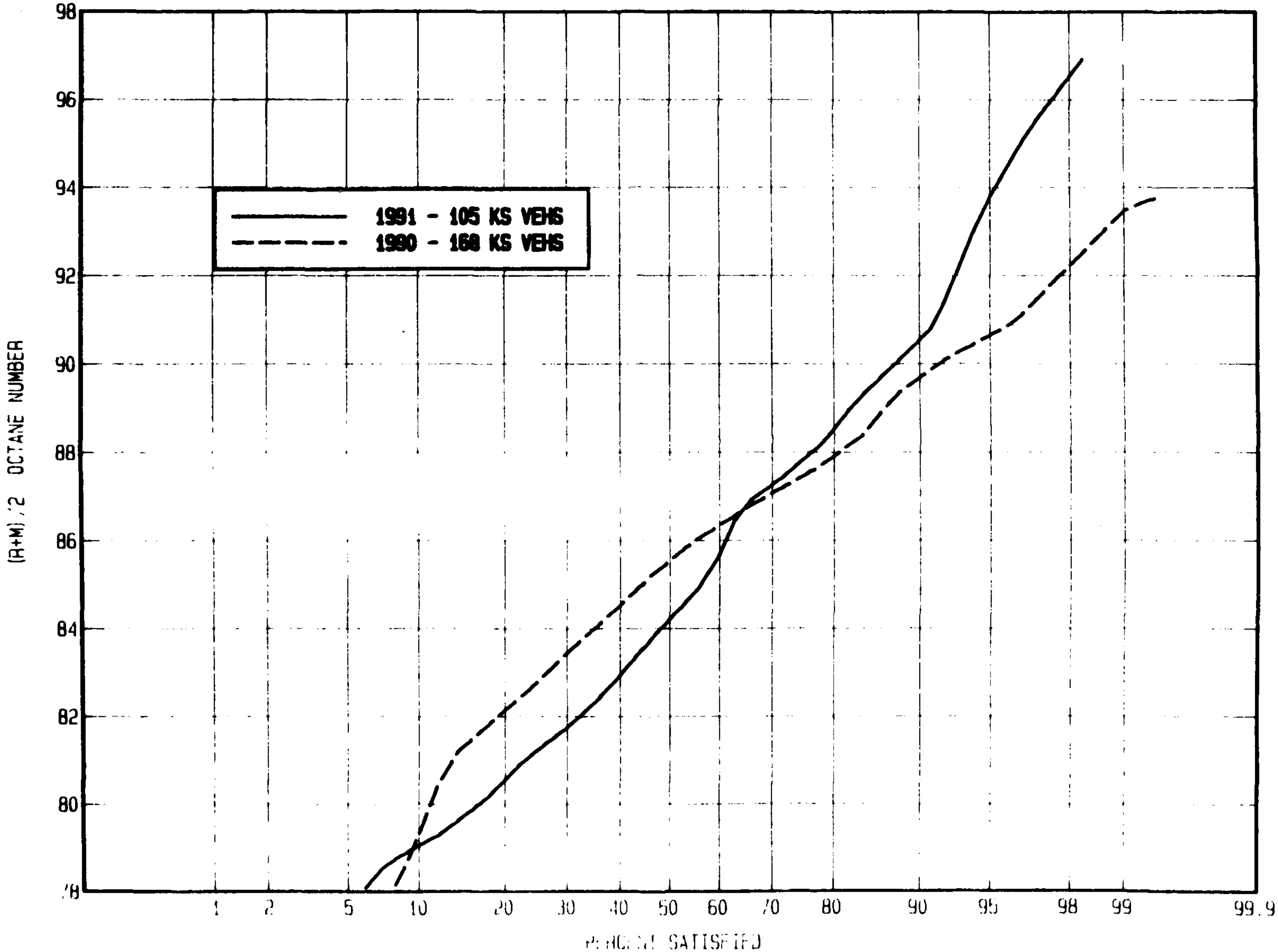


Figure 17

DISTRIBUTION OF MAXIMUM FBRU FUEL (R+M)/2 OCTANE NUMBER REQUIREMENTS

1991 AND 1990 KNOCK SENSOR VEHICLES



APPENDIX A

PARTICIPATING LABORATORIES

PARTICIPATING LABORATORIES

No. of Vehicles Tested	Eastern Area	East Central Area	No. of Vehicles Tested
1	Exxon Res. & Engrg. Co. Linden, NJ	BP Oil Company Cleveland, OH	30
30	Mobil Res. & Dev. Corp. Paulsboro, NJ	Ford Motor Company Dearborn, MI	16
11	Sun Company Marcus Hook, PA	General Motors Research Labs Warren, MI	30
30	Texaco Inc. Beacon, NY	Nissan Res. & Dev. Ann Arbor, MI	3
		Shell Canada Oakville, Ontario	13
		Toyota Motor Corp. Ann Arbor, MI	5

	Western Area	West Central Area	
27	Chevron Res. & Technology Co. Richmond, CA	Amoco Oil Company Naperville, IL	29
25	Unocal Corporation Brea, CA	Phillips Petroleum Co. Bartlesville, OK	7
		Shell Development Co. Houston, TX	5

APPENDIX B

MEMBERSHIP: 1991 ANALYSIS PANEL

1991 CRC OCTANE NUMBER REQUIREMENT SURVEY

1991 ANALYSIS PANEL

Name	Company
C. J. Bonés, Leader	Mobil Research and Development Corporation
W. F. Biller	Consultant
R. A. Bouffard	Exxon Research and Engineering Company
J. P. Graham	Chevron Research and Technology Company
C. T. Siambekos	Amoco Oil Company
J. P. Uihlein	BP Oil Company
T. Wusz	Unocal Corporation

APPENDIX C

DATA ON 1991/1992
FULL-BOILING RANGE REFERENCE FUELS

TABLE C-1

SUPPLIERS' FUEL INSPECTIONS

1991/1992 FBRU FUELS

	Low-Octane Base Blend RMFD 377-91/92	Intermediate-Octane Base Blend RMFD 378-91/92	High-Octane Base Blend RMFD 379-91/92
Laboratory Inspection			
Distillation, °F			
IBP	97	85	97
10% Evap.	141	113	136
30% Evap.	172	151	184
50% Evap.	191	195	232
70% Evap.	213	245	254
90% Evap.	317	336	290
End Point	437	412	386
RVP, psi	7.5	8.9	7.3
Lead, g/gal.	0.000	0.000	0.000
Oxidation Stab., min.	1440+	1440+	1440+
Hydrocarbon Type, Vol. %			
Aromatics	11.2	27.4	43.9
Olefins	8.0	11.8	2.4
Saturates	80.8	60.8	53.7
Research Octane Number	75.8	91.4	104.2
Motor Octane Number	72.7	82.8	92.6
Sensitivity	3.1	8.6	11.6

TABLE C-2

OCTANE NUMBERS AND COMPOSITIONS FOR 1991/1992 FBRU FUELS

Research Octane Number	Volume Percent RMFD 377-91/92	RMFD 378-91/92	RMFD 379-91/92	Motor Octane Number	Sensitivity
80	76.8	23.2	---	75.7	4.3
82	64.2	35.8	---	76.8	5.2
84	51.2	48.8	---	78.0	6.0
85	44.6	55.4	---	78.6	6.4
86	37.9	62.1	---	79.3	6.7
87	31.1	68.9	---	79.9	7.1
88	24.3	75.7	---	80.5	7.5
89	17.3	82.7	---	81.2	7.8
90	10.3	89.7	---	81.8	8.2
91	3.3	96.7	---	82.5	8.5
92	---	96.3	3.7	82.8	9.2
93	---	88.6	11.4	83.5	9.5
94	---	80.9	19.1	84.3	9.7
95	---	73.1	26.9	85.0	10.0
96	---	65.2	34.8	85.8	10.2
97	---	57.2	42.8	86.6	10.4
98	---	49.2	50.8	87.3	10.7
99	---	41.0	59.0	88.1	10.9
100	---	32.8	67.2	88.9	11.1
101	---	24.5	75.5	89.7	11.3
102	---	16.1	83.9	90.5	11.5
103	---	7.7	92.3	91.3	11.7

TABLE C-3

SUPPLIERS' FUEL INSPECTIONS

1991/1992 FBRSU FUELS

	Low-Octane Base Blend RMFD 380-91/92	Intermediate-Octane Base Blend RMFD 381-91/92	High-Octane Base Blend RMFD 382-91/92
Laboratory Inspection			
Distillation, °F			
IBP	99	94	96
10% Evap.	142	134	136
30% Evap.	179	170	186
50% Evap.	205	214	232
70% Evap.	238	273	255
90% Evap.	357	366	306
End Point	423	428	403
RVP, psi	7.7	7.4	8.4
Lead, g/gal.	0.000	0.000	0.000
Oxidation Stab., min.	1440+	1440+	1440+
Hydrocarbon Type, Vol. %			
Aromatics	18.5	41.1	50.6
Olefins	28.0	21.4	1.8
Saturates	53.5	37.5	47.6
Research Octane Number	76.3	91.7	104.2
Motor Octane Number	70.4	80.7	90.5
Sensitivity	5.9	11.0	13.7

TABLE C-4

OCTANE NUMBERS AND COMPOSITIONS FOR 1991/1992 FBRSU FUELS

Research Octane Number	Volume Percent RMFD 380-91/92	RMFD 381-91/92	RMFD 382-91/92	Motor Octane Number	Sensitivity
80	79.9	20.1	---	72.9	7.1
82	67.0	33.0	---	74.1	7.9
84	53.9	46.1	---	75.4	8.6
85	47.2	52.8	---	76.1	8.9
86	40.4	59.6	---	76.8	9.2
87	33.6	66.4	---	77.4	9.6
88	26.6	73.4	---	78.1	9.9
89	19.6	80.4	---	78.8	10.2
90	12.5	87.5	---	79.5	10.5
91	5.4	94.6	---	80.2	10.8
92	---	97.8	2.2	80.7	11.3
93	---	89.9	10.1	81.5	11.5
94	---	81.9	18.1	82.2	11.8
95	---	73.8	26.2	83.0	12.0
96	---	65.6	34.4	83.8	12.2
97	---	57.3	42.7	84.5	12.5
98	---	49.0	51.0	85.3	12.7
99	---	40.6	59.4	86.1	12.9
100	---	32.0	68.0	87.0	13.0
101	---	23.4	76.6	87.8	13.2
102	---	14.7	85.3	88.6	13.4
103	---	6.0	94.0	89.4	13.6

TABLE C-5

SUPPLIERS' FUEL INSPECTIONS

1991/1992 FBRUM FUELS

	Low-Octane Base Blend RMFD 383-91/92	Intermediate-Octane Base Blend RMFD 384-91/92	High-Octane Base Blend RMFD 385-91/92
Laboratory Inspection			
Distillation, °F			
IBP	97	90	91
10% Evap.	139	127	129
30% Evap.	160	154	162
50% Evap.	180	186	212
70% Evap.	208	244	246
90% Evap.	311	331	285
End Point	425	422	380
RVP, psi	7.7	8.6	8.0
Lead, g/gal.	0.000	0.000	0.000
Hydrocarbon Type, Vol. %			
Aromatics	9.3	25.0	37.5
Olefins	6.5	8.5	0.8
Saturates	69.2	51.5	46.7
MTBE, Vol. %	15.0	15.0	15.0

TABLE C-6

OCTANE NUMBERS AND COMPOSITIONS FOR 1991/1992 FBRUM FUELS

Research Octane Number	Volume Percent RMFD 383-91/92	RMFD 384-91/92	RMFD 385-91/92	Motor Octane Number	Sensitivity
84	97.2	2.8	---	79.7	4.3
85	89.2	10.8	---	80.1	4.9
86	81.2	18.8	---	80.6	5.4
87	73.0	27.0	---	81.1	5.9
88	64.8	35.2	---	81.6	6.4
89	56.4	43.6	---	82.1	6.9
90	48.0	52.0	---	82.6	7.4
91	39.5	60.5	---	83.1	7.9
92	30.9	69.1	---	83.6	8.4
93	22.1	77.9	---	84.1	8.9
94	13.3	86.7	---	84.6	9.4
95	4.4	95.6	---	85.1	9.9
96	---	93.6	6.4	85.5	10.5
97	---	84.3	15.7	86.3	10.7
98	---	75.1	24.9	87.1	10.9
99	---	65.8	34.2	87.8	11.2
100	---	56.5	43.5	88.6	11.4
101	---	47.2	52.8	89.3	11.7
102	---	37.9	62.1	90.1	11.9
103	---	28.7	71.3	90.8	12.2
104	---	19.4	80.6	91.6	12.4
105	---	10.1	89.9	92.3	12.7

APPENDIX D

PROGRAM

COORDINATING RESEARCH COUNCIL
INCORPORATED
219 PERIMETER CENTER PARKWAY
ATLANTA, GEORGIA 30346
(404) 396-3400

Not to be Published

PROGRAM

for the

1991 CRC OCTANE NUMBER REQUIREMENT SURVEY

CRC Project No. CM-123-91

MARCH 1991

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TEXT OF PROGRAM

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I. INTRODUCTION

The 1991 program of the CRC Light-Duty Octane Number Requirement Survey Group will consist of a survey of the octane number requirements of 1991 model domestic and imported vehicles. For the purposes of this program, the designation "passenger vehicles" will include passenger cars, light-duty (<8500 lb/3856 kg GVW) pickup trucks, and vans. Approximately 450 vehicles will be tested. Most of these vehicles will be sampled in proportion to their relative production or import volume, to provide data from which to estimate the distribution of octane number requirements for the 1991 model vehicle population in the United States. In addition, select models of special interest will be tested in sufficient numbers to estimate their requirement distributions.

Knocking characteristics will be investigated with four series of reference fuels. Tank fuel knock will also be evaluated. Maximum octane number requirements, whether at maximum-throttle or part-throttle, will be established for each vehicle using high sensitivity unleaded full-boiling range reference (FBRSU) fuels, average sensitivity unleaded full-boiling range reference (FBRU) fuels, primary reference (PR) fuels, and full-boiling range unleaded MTBE (FBRUM) fuels. If the maximum requirement is at maximum-throttle, then part-throttle requirements are investigated with only FBRU fuels of up to, and including, four octane numbers lower than the maximum requirement.

II. GEOGRAPHICAL AREAS

As in previous years, the 1991 Survey will be conducted on a nationwide basis for the US, and will include Canada. Four geographical areas have been established for test vehicle assignment purposes. Participants located in New York, New Jersey, and Pennsylvania are included in the Eastern Area; those located in Ohio, Michigan, and Kentucky comprise the East Central Area; those in Illinois, Texas, and Oklahoma comprise the West Central Area; and California participants make up the Western Area. Canadian participants are assigned to either the East or East Central Areas. Coordinators for each of the areas are as follows:

Eastern Area.......................D. I. Hoel
East Central Area..................J. P. Uihlein
West Central Area..................D. A. Barker
Western Area.......................T. Wusz

The area coordinators will contact their area participants periodically regarding the progress of the survey. To expedite this, it is suggested that participants send copies of all correspondence concerning the survey to the area coordinators. This program outlines the survey in broad terms. If more detailed information is desired, it is suggested that the participant contact his area coordinator.

III. VEHICLES

A total of approximately 420 vehicles will be tested in the 1991 Survey. Current experience indicates we can expect about 14 full participants and 5 partial participants. The 420-vehicle total will be divided into two groups: (1) the statistical group, sampled in proportion to US car model production or import volume, and (2) select models of special interest. Approximately 10 of each of these select models will be added to their statistical assignment in order to provide an estimate of the octane requirement distribution of each model.

The desired number of vehicles to be tested in each category is as follows:

Statistical Group	390
Additional Select Model Group	30
Total	420

A detailed breakdown of the specific models and the number of each model to be tested will be circulated to the participants after an estimate of vehicle model production has been obtained. Design specifications for select models to be tested in the 1991 Survey are shown in Table D-I. Selection of these vehicles has been based on new or modified design characteristics that might have a significant effect on octane number requirements and high sales volume which allows individual treatment without additional testing.

Wherever possible, specific vehicle assignments to individual participating laboratories will be made in a pattern which tends to minimize data bias. This will be accomplished by apportioning cars of a given model among the four geographical areas, and subsequently among the laboratories within each area, in order to minimize the effect of non-random factors on the results of the Survey.

IV. FUELS

A. Full-Boiling Range Reference Fuels

Three full-boiling range reference fuel series will be used to define the vehicle octane number requirements. The three series will be unleaded and of varying sensitivity. One series will be comparable to the average sensitivity of unleaded commercial fuels (FBRU); another series (FBRSU) will be a minimum of two numbers higher in sensitivity than the FBRU fuels; and the third series (FBRUM) will be made by blending the FBRU fuels with 15 volume percent MTBE. The Research octane number (RON) range for the FBRU and FBRSU fuel series is 75 to 104. The Research octane number of the FBRUM fuel series will range higher than the other fuels and will be determined by the Fuel Acceptance Panel.

These fuels will be blended in increments of two RON up to 84, and one RON above 84 from three base fuels for each series. The base fuels are compounded from normal refinery gasoline components. Limiting specifications for each base fuel for each series are shown in Table D-II. Supplier inspection data are shown in Table D-III.

Research and Motor ratings will be determined for incremental blends of each fuel series by participants to provide data for establishment of blending curves. The average ratings and blending curves appear in Tables D-IV through D-VI.

B. Primary Reference Fuels

Blends of ASTM-grade isooctane and normal heptane will be prepared in two octane number increments from 76 to 82, and one octane number increments from 82 to 100.

C. Tank Gasoline

Research and Motor octane ratings will be obtained only on gasoline samples from the tank of vehicles for which an owner's questionnaire has been completed (Attachment 1). Owner's Questionnaire should be obtained if:

a) vehicle has a regular driver; and

b) the ignition timing is within $\pm$ 2° of the manufacturer's specifications.

V. TEST TECHNIQUE

All tests are to be conducted using the technique entitled, "Technique for Determination of Octane Number Requirements of Light-Duty Vehicles" (CRC Designation E-15-91). A copy of this technique is included as Attachment 2 to this program. Octane number requirement investigations are to be conducted in all vehicles under level road conditions. Any vehicle obviously in poor mechanical condition or with malfunctioning emission control devices should not be considered for test work. The vehicles must have a minimum of 6000 deposit miles (9656 km), and preferably be privately owned and operated. Data with less than 6000 miles will not be analyzed. Vehicles previously used for fuel road octane rating must not be employed in this survey.

Data should be reported on each vehicle tested, even though knock was not encountered on any of the fuels.

The order in which the fuels are to be tested is as follows:

1) Tank fuel;
2) FBRSU;
3) FBRU;
4) PR;
5) FBRUM.

VI. DATA FORMS

The test results on each vehicle will be reported on Data Form ONRS-91 (Attachment 3). Copies of these forms will be mailed to all participants from the CRC office with instructions for their use. Additional instructions are included in the E-15-91 technique.

VII. REPORTING RESULTS

The original data forms for each vehicle tested should be submitted to William F. Biller, 68 Yorktown Road, East Brunswick, New Jersey 08816, as soon as possible, but not later than October 31, 1991.

TABLE D-I

DESIGN SPECIFICATIONS FOR 1991 SELECT MODELS

Make & Model	Engine Displ. Liters	Configuration & No. of Cylinders	Fuel System	Comp. Ratio	BHP	Knock-Sensor	VIN Engine Code	Trans. Type
Chrysler New Yorker/ Imperial/Caravan/ Voyager	3.3	V-6	PFI	8.9	147	NO	8th digit R	A-4

TABLE D-II

LIMITING SPECIFICATIONS FOR 1991 AND 1992 FULL-BOILING RANGE REFERENCE FUELS*

Inspection Tests	Unleaded Average Sensitivity Reference Fuels (FBRU) RMFD 377		RMFD 378	RMFD 379	Unleaded High Sensitivity Reference Fuels (FBRSU) RMFD 380	RMFD 381	RMFD 382
ASTM Distillation, $^{o}F(^{o}C)$							
IBP, Min.	90	(32.2)	90	90	90	90	90
10% Evap.	115-158	(46.1- 70.0)	115-158	115-158	115-158	115-158	115-158
30% Evap.	150-190	(65.6- 87.8)	150-190	150-190	150-190	150-190	150-190
50% Evap.	195-250	(90.6-121.1)	195-250	195-250	195-250	195-250	195-250
70% Evap.	230-300	(110.0-148.9)	230-300	230-300	230-300	230-300	230-300
90% Evap.	285-374	(140.6-190.0)	285-374	285-374	285-374	285-374	285-374
End Point, Max.	437	(225)	437	437	437	437	437
RVP, psi (KPa)	7-9	(48-62)	7-9	7-9	7-9	7-9	7-9
Lead, g/gal (g/l)	<0.03	(<0.008)	<0.03	<0.03	<0.03	<0.03	<0.03
Oxidation Stability, Minutes, Min.	1440		1440	1440	1440	1440	1440
Hydrocarbon Type, Vol. %							
Aromatics, Max.**	20		35	55	35	45	65
Olefins, Max.	20		15	10	35	25	15
Saturates	Remainder		Remainder	Remainder	Remainder	Remainder	Remainder
Octane Number							
Research	75 ± 1		91 ± 1	104 ± 1	75 ± 1	91 ± 1	104 ± 1
Sensitivity***	3.0 ± .5		8.5 ± .5	11.5 ± .5	5.0 ± .5	10.5 ± .5	13.5 ± .5
Minimum of two units sensitivity difference between corresponding fuels of each series.							
Color	Bronze		Green	Red	Yellow	Deep Purple	Light Blue

Note: All fuels to contain minimum 5 PTB of a 100% active antioxidant and 10 PTB of corrosion inhibitor. No manganese added.
Confirmation of product quality of fuel blends to be approved by a six-laboratory CRC Fuel Acceptance Panel prior to drumming.

* To be compounded from normal refinery components. RMFD-383 through RMFD-385 (FBRUM) are to be blended by adding 15% MTBE (≥ 98% purity) to the FBRU fuels.

** 1% maximum Benzene or legal.

*** Sensitivities are shown for the mean Research octane number.

TABLE D-III

SUPPLIER INSPECTION DATA FOR 1991 AND 1992 FULL-BOILING RANGE REFERENCE FUELS

Inspection Tests	Unleaded Average Sensitivity Reference Fuels (FBRU)			Unleaded High Sensitivity Reference Fuels (FBRSU)			15% MTBE Reference Fuels (FBRUM)		
	RMFD 377	RMFD 378	RMFD 379	RMFD 380	RMFD 381	RMFD 382	RMFD 383	RMFD 384	RMFD 385
ASTM Distillation, ^{o}F									
IBP	97	85	97	99	94	96	97	90	91
10% Evap.	141	113	136	142	134	136	139	127	129
30% Evap.	172	151	184	179	170	186	160	154	162
50% Evap.	191	195	232	205	214	232	180	186	212
70% Evap.	213	245	254	238	273	255	208	244	246
90% Evap.	317	336	290	357	366	306	311	331	285
Endpoint	437	412	386	423	428	403	425	422	380
RVP, psi	7.5	8.9	7.3	7.7	7.4	8.4	7.7	8.6	8.0
Lead, g/gal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Oxidation Stability, Minutes	1440+	1440+	1440+	1440+	1440+	1440+	--	--	--
Hydrocarbon Type, Vol. %									
Aromatics	11.2	27.4	43.9	18.5	41.1	50.6	10.5	29.4	44.5
Olefins	8.0	11.8	2.4	28.0	21.4	1.8	7.6	10.0	0.9
Saturates	80.8	60.8	53.7	53.5	37.5	47.6	81.9	60.6	54.6
Octane Number									
Research	75.8	91.4	104.2	76.3	91.7	104.2	--	--	--
Sensitivity	3.1	8.6	11.6	5.9	11.0	13.7	--	--	--

TABLE D-IV

COMPOSITIONS AND OCTANE NUMBERS

FOR CRC 1991-92 FBRU REFERENCE FUELS

Research Octane Number	Volume Percent RMFD 377	Volume Percent RMFD 378	Volume Percent RMFD 379	Motor Octane Number	Sensitivity
80	76.8	23.2	----	75.7	4.3
82	64.2	35.8	----	76.8	5.2
84	51.2	48.8	----	78.0	6.0
85	44.6	55.4	----	78.6	6.4
86	37.9	62.1	----	79.3	6.7
87	31.1	68.9	----	79.9	7.1
88	24.3	75.7	----	80.5	7.5
89	17.3	82.7	----	81.2	7.8
90	10.3	89.7	----	81.8	8.2
91	3.3	96.7	----	82.5	8.5
92	----	96.3	3.7	82.8	9.2
93	----	88.6	11.4	83.5	9.5
94	----	80.9	19.1	84.3	9.7
95	----	73.1	26.9	85.0	10.0
96	----	65.2	34.8	85.8	10.2
97	----	57.2	42.8	86.6	10.4
98	----	49.2	50.8	87.3	10.7
99	----	41.0	59.0	88.1	10.9
100	----	32.8	67.2	88.9	11.1
101	----	24.5	75.5	89.7	11.3
102	----	16.1	83.9	90.5	11.5
103	----	7.7	92.3	91.3	11.7

TABLE D-V

COMPOSITIONS AND OCTANE NUMBERS

FOR CRC 1991-92 FBRSU REFERENCE FUELS

Research Octane Number	Volume Percent RMFD 380	RMFD 381	RMFD 382	Motor Octane Number	Sensitivity
80	79.9	20.1	----	72.9	7.1
82	67.0	33.0	----	74.1	7.9
84	53.9	46.1	----	75.4	8.6
85	47.2	52.8	----	76.1	8.9
86	40.4	59.6	----	76.8	9.2
87	33.6	66.4	----	77.4	9.6
88	26.6	73.4	----	78.1	9.9
89	19.6	80.4	----	78.8	9.2
90	12.5	87.5	----	79.5	10.5
91	5.4	94.6	----	80.2	10.8
92	----	97.8	2.2	80.7	11.3
93	----	89.9	10.1	81.5	11.5
94	----	81.9	18.1	82.2	11.8
95	----	73.8	26.2	83.0	12.0
96	----	65.6	34.4	83.8	12.2
97	----	57.3	42.7	84.5	12.5
98	----	49.0	51.0	85.3	12.7
99	----	40.6	59.4	86.1	12.9
100	----	32.0	68.0	87.0	13.0
101	----	23.4	76.6	87.8	13.2
102	----	14.7	85.3	88.6	13.4
103	----	6.0	94.0	89.4	13.6

TABLE D-VI

COMPOSITIONS AND OCTANE NUMBERS

FOR CRC 1991-1992 FBRUM REFERENCE FUEL

Research Octane Number	Volume Percent RMFD 383	RMFD 384	RMFD 385	Motor Octane Number	Sensitivity
84	97.2	2.8	----	79.7	4.3
85	89.2	10.8	----	80.1	4.9
86	81.2	18.8	----	80.6	5.4
87	73.0	27.0	----	81.1	6.9
88	64.8	35.2	----	81.6	7.4
89	56.4	43.6	----	82.1	6.9
90	48.0	52.0	----	82.6	7.4
91	39.5	60.5	----	83.1	7.9
92	30.9	69.1	----	83.6	8.4
93	22.1	77.9	----	84.1	8.9
94	13.3	86.7	----	84.6	9.4
95	4.4	95.6	----	85.1	9.9
96	----	93.6	6.4	85.5	10.5
97	----	84.3	15.7	86.3	10.7
98	----	75.1	24.9	87.1	10.9
99	----	65.8	34.2	87.8	11.2
100	----	56.5	43.5	88.6	11.4
101	----	47.2	52.8	89.3	11.7
102	----	37.9	62.1	90.1	11.9
103	----	28.7	71.3	90.8	12.2
104	----	19.4	80.6	91.6	12.4
105	----	10.4	89.9	92.3	12.7

Attachment 1

CRC OCTANE NUMBER REQUIREMENT SURVEY

OWNER'S QUESTIONNAIRE

OWNER:

Your vehicle is being tested for fuel octane number requirements by a Coordinating Research Council activity. To help analyze the data, we would like the person who has recently been driving the vehicle to answer the following questions:

1. What grade of unleaded fuel was purchased the last two times?

   ☐ Regular ☐ Mid-Grade ☐ Premium

2. Has any engine knock (ping) been encountered with the fuel that is now in the tank?

   ☐ Yes ☐ No

3. If engine knock (ping) has been encountered, did you consider the knock (ping) objectionable?

   ☐ Yes ☐ No

Vehicle Make ____________________ License No. ____________________

Vehicle Identification No. ____

Company Testing Vehicle ____

Attachment 2

TECHNIQUE FOR DETERMINATION OF OCTANE NUMBER REQUIREMENTS OF LIGHT-DUTY VEHICLES

(CRC Designation E-15-91)

MARCH 1991

I. OBJECTIVE

This procedure establishes the octane number requirements of light-duty vehicles, under defined test conditions. Testing will be conducted with a series of reference fuels using full-throttle and part throttle accelerations and transient-throttle maneuvers.

II. OVERVIEW OF TEST PROCEDURE

A. Test Procedure

The first step in octane rating is to determine the transmission characteristics of the vehicle. This information tells the driver what engine speed and manifold vacuum is used to obtain the engine conditions needed to measure octane requirement. The transmission characteristic information is not part of the octane requirement data, but is obtained as an aid to the driver.

The maximum octane requirement of the vehicle is the highest octane number fuel in a fuel series which causes borderline knock in at least one engine condition. When the highest knocking fuel causes above-borderline knock, the maximum octane requirement is intermediate between that fuel and the next highest non-knocking fuel. A maximum octane requirement is determined on each of the fuel series. The part-throttle requirement on the FBRU fuel series is investigated and reported in the octane number interval up to four numbers less than the wide-open-throttle requirement.

B. Data Forms

Data Form ONRS-MY* consists of four sides: A, B, C, D. Side A includes company information, vehicle data, weather data, knock data on tank fuel, and the octane number requirement summary. Completion of the octane number requirement summary is discussed in Section IX. Side B has a table for transmission characteristic information. This information is located for convenient reference during the octane rating procedure. Side B also has a check list of items to be used during vehicle preparation. Side C is used during the octane rating procedure to record the data from all accelerations, whether they give knock or not.

*MY = current model year

Side D continues the data from side C. It also contains footnote references for the entire form and space for any comments the rater wishes to make. If the rating procedure requires more space for data than is provided in sides C and D, additional C and D sides should be used.

A completed Owner's Questionnaire Form ONRS-MY, Side E should be obtained if the vehicle has a regular driver and the engine spark timing has not been adjusted for testing.

III. TEST PREPARATION

The vehicle must be prepared to operate as the manufacturer intended, but with an auxiliary fuel system. Care should be exercised when preparing the vehicle for testing to ensure that the test reflects normal operating conditions.

A. Vehicle Inspection

Vehicles should be inspected to ensure that engine operation is correct. A list of required items to check is included on ONRS-MY, Side B. This list is a guide only. Individual laboratories may choose to check additional vehicle characteristics.

B. Test Equipment Installation

A calibrated tachometer graduated in 100 rpm (or smaller) increments and capable of indicating engine speed from 0-5000 rpm shall be installed on the vehicle. Analog tachometers are preferable.

One calibrated vacuum gauge, graduated in one-half inch of mercury (or smaller) increments and capable of indicating vacuum from 0-24 inches of mercury (0-81 kPa) shall be connected to the intake manifold. For vehicles with turbochargers or superchargers, a compound vacuum/pressure gauge should be used; the pressure side of the gauge should be capable of indicating pressures up to 15 psig (103 kPa).

An auxiliary fuel system shall be provided to supply test fuels to the engine. Fuel pressure and fuel line size should meet manufacturer's specifications. Auxiliary fuel systems are fuel-system-type-specified and instructions are given in Appendix A.

The vehicle's evaporative emission canister should be disconnected and plugged at the outlet to the engine. A slave canister that is clear of residual vapor should be installed on the vehicle, and normal engine connections should be made. The original vehicle canister must be left in place, and the line from the tank must remain connected to it. Connections need not be made between the slave canister and the auxiliary fuel system.

C. Data Recording

Record vehicle identification number and emission control type, Federal, Altitude, California, or Fifty-State. Fill in headings on Data Form ONRS-MY, Sides A and C. Ford emission calibration numbers are to be recorded.

Record basic spark timing before adjustment to manufacturer's specifications.

For vehicles with owner questionnaire completed for the ONRS, a sample of the tank gasoline shall be withdrawn for determination of Research and Motor octane number ratings. If insufficient fuel is available, omit this step and tank fuel observations.

IV. TEST CONDITIONS

All octane number requirements will be determined under level road acceleration conditions. Noise in the passenger compartment should be similar to noise encountered during normal road conditions. Windows should be closed or sealed, and the radio should be off. If testing is to be conducted on a chassis dynamometer, coastdown and/or acceleration data should be used to determine dynamometer load (level road conditions).

Tests will be conducted in moderately dry conditions, preferably at ambient temperatures between 60°F (16°C) and 90°F (32°C). Tests should not be conducted during periods of high humidity such as prevail when rain is threatening or during or immediately after a rain storm. Laboratories with control capabilities should target for 70°F (21°C) air temperature and 50 grains of water per pound (7.14 gm/kg) of dry air whenever possible. Record temperature, pressure, and humidity on the data form.

A procedure to stabilize vehicle operating temperatures and to acclimate the engine control system to the test fuel is described below. The warm-up and stabilization cycle should be a replicate of the first 505 seconds of the Federal Test Procedure (FTP) cycle. It should be initiated with the ignition key in the off position for five seconds. The ignition key should be returned to the off position for five seconds at the completion of the warm-up and stabilization cycle. Vehicles should be driven through the warm-up and stabilization cycle three times in order to achieve a ten-mile warm-up. The initial vehicle warm-up will be conducted with tank fuel if an owner's questionnaire is present. Otherwise, the initial warm-up should be conducted with a non-knocking hydrocarbon-only fuel. Following the tank fuel rating, the vehicle should be re-stabilized with two 505-second cycles using a non-knocking hydrocarbon-only fuel. Because the stoichiometry of the FBRUM fuel is significantly different from the other test fuel series, the warm-up and stabilization procedure should also be conducted between the PR and FBRUM fuels series. A non-knocking FBRUM fuel should be utilized for warm-up and stabilization. A 15 volume percent MTBE and non-knocking hydrocarbon blend can be substituted for the FBRUM fuel for warm-up, if fuels are short.

During the warm-up period, the general mechanical condition of the vehicle should be checked to ensure satisfactory and safe operation during test work.

Air-conditioned vehicles will be tested with air conditioner turned ON in the normal mode, set at a comfortable temperature, with low fan.

V. FUELS

Octane number requirements are determined using the vehicle's tank fuel, and four reference fuel series.

Vehicle tank fuel is tested to obtain a preliminary indication of the vehicle octane number requirement. It will also be octane-rated and data included on Data Form ONRS-MY, Side A, if an Owner's Questionnaire Form ONRS-MY, Side E has been completed.

Octane number requirements are also determined using four reference fuel series. Two are designed using typical refinery components and are blended from three base blends in one or two Research octane numbers (RON) increments.

Full-Boiling Range Unleaded (FBRU) fuels are blended to a typical octane sensitivity. Octane sensitivity is defined as the difference between the fuel's RON and Motor octane number (MON) ratings.

Full-Boiling Range Sensitive Unleaded (FBRSU) fuels are blended to a target sensitivity two octane numbers higher than the FBRU fuel.

Full-Boiling Range Unleaded MTBE (FBRUM) fuels are blended by adding 15 volume percent MTBE to the FBRU fuels.

Primary Reference (PR) fuels comprise the fourth reference fuel series and are a volume blend of two components, isooctane and normal heptane. PR fuels are blended in one or two octane number increments, and by definition have zero sensitivity. PR fuels are defined in ASTM D2699 and D2700 test procedures.

Fuels are tested in a specific order. Tank fuel is tested first. The reference fuels are tested in order of descending sensitivity, except for the FBRUM fuel which will be tested last.

VI. DETERMINATION OF AUTOMATIC TRANSMISSION CHARACTERISTICS

Automatic transmission vehicles should be tested with the gear selector in the top forward gear, normally found to the right or below neutral; top gear should not be locked out unless noted otherwise by the manufacturer. Transmissions equipped with automatic overdrive should be operated in overdrive unless noted otherwise by the manufacturer. Transmissions equipped with power/normal selection should be operated in the normal position.

Do not use brakes, turn signals, or hazard flashers during accelerations, as these may affect electronic engine controls.

Determine the minimum road speed for converter clutch applications in each gear by gently acceleration from the minimum speed to obtain the gear until the converter clutch engages. Record manifold vacuum, engine rpm, and vehicle speed on Data Form ONRS-MY, Side B.

Obtain the transmission downshift characteristics to define the detent curve for the gear/converter clutch combination.

1) Starting from a constant speed of 25 mph (40 kph), open the throttle until downshift occurs. Observe manifold vacuum and engine rpm.

2) Repeat Step 1 at higher vacuums until a vacuum is found which does not cause downshift. Record vacuum and rpm.

3) Repeat Steps 1 and 2, starting, in succession, from 35, 45, 55, and 65 mph (56, 72, 88, and 105 kph), and in all available gear/converter clutch combinations available at each speed.

VII. DRIVING PROCEDURES

Octane number requirements will be evaluated under both full-throttle and part-throttle accelerations. The vehicles will be evaluated to determine the transmission gear position and throttle position of maximum knock intensity, which is the critical operating condition.

A. Manual Transmissions

Accelerations will not be made in all transmission gears. Accelerations and critical vacuum/pressure determinations will be investigated per the following gear selection table:

5-speed	4th and 3rd gears
4-speed	4th and 3rd gears
3-speed	3rd and 2nd gears

Accelerations will start from the lowest speed from which the vehicle will accelerate smoothly or 25 mph (40 kph), whichever is higher.

Full-throttle accelerations are made with the throttle fully depressed.

Part-throttle accelerations are made with the throttle depressed at least one inch Hg (3.3 kPa) higher than the full-throttle manifold vacuum/pressure. Part-throttle accelerations start at the minimum obtainable speed in the test gear to 70 mph (113 kph), or until the vehicle ceases to accelerate reasonably. Part-throttle accelerations to measure vehicle octane number requirements are performed at critical vacuum/pressures.

To obtain critical part-throttle vacuum/pressure, operate at constant speed road load at 25, 35, 45, 55, and 65 mph (40, 56, 72, 88, and 105 kph) incremental speeds. At each speed, move the throttle from road load vacuum to the positions described below:

For naturally-aspirated vehicles, one inch Hg (3.3 kPa) above full-throttle vacuum;

For turbocharged vehicles, one inch Hg (0.5 psig or 3.3 kPa) below maximum boost.

The throttle movement from road load to the prescribed position should take place in approximately three seconds. This procedure is called fanning. If knocking occurs within any of the vacuum/pressure ranges, establish the manifold vacuum/pressure which gives maximum knock intensity. This is the critical vacuum/pressure to be used for all subsequent constant-vacuum/pressure part-throttle accelerations.

The critical part-throttle vacuum/pressure may be different for other fuel series and must be reinvestigated for each series.

Use of vehicle brakes must be avoided.

B. Automatic Transmissions

Accelerations must be made with the selector in the top forward gear, normally found to the right or below neutral; top gear should not be locked out. Transmissions equipped with electronic overdrive should be operated in overdrive. Transmissions equipped with power/normal selections should be operated in the normal position.

Accelerations will not be made in all transmissions gears. Accelerations and critical vacuum/pressure determinations will be done as shown in the following gear table. If a particular gear/lock-up combination cannot be obtained, it will not be tested.

Type	Gears to be Tested
4-speed with torque converter lock-up	4th gear, converter clutch engaged 4th gear, converter clutch disengaged 3rd gear, converter clutch engaged 3rd gear, converter clutch disengaged 2nd gear, converter clutch disengaged
4-speed without torque converter lock-up	4th gear 3rd gear 2nd gear
3-speed with torque converter lock-up	3rd gear, converter clutch engaged 3rd gear, converter clutch disengaged 2nd gear, converter clutch disengaged
3-speed without torque converter lock-up	3rd gear 2nd gear

Accelerations in each of the transmission gears or gear/converter clutch combinations specified above will start from the minimum obtainable road speed and continue until maximum test speed is obtained or, in the case of part-throttle, the vehicle ceases to accelerate reasonably. Minimum obtainable road speeds were established when automatic transmission characteristics were investigated in Section VI. Maximum test speed is 70 mph or a road speed corresponding to 750 rpm above maximum torque, whichever is lower. If the transmissions downshifts, abort and start the acceleration again.

Full-throttle accelerations are made with the throttle depressed in the widest throttle position that does not cause the transmission to downshift or the torque converter clutch to disengage. These accelerations are made following the speed-vacuum/pressure curves established in Section VI.

Part-throttle accelerations are made with the throttle depressed at least one inch Hg (3.3 kPa) higher than the full-throttle manifold vacuum/pressure. Part-throttle accelerations start at the minimum obtainable speed in the test gear to 70 mph (113 kph), or until the vehicle ceases to accelerate reasonably. Part-throttle accelerations to measure vehicle octane number requirements are performed at critical vacuum/pressures.

The critical part-throttle vacuum/pressure investigations will be conducted in the two highest transmission gear positions with the available combinations of converter clutch locked or unlocked. Investigation of critical condition should start with the highest transmission gear with converter clutch engaged. Begin from road load speed of 25 mph (40 kph) or minimum obtainable road speed for the gear/converter clutch combination. Continue the investigation at speeds of 35, 45, 55, and 65 mph (56, 72, 88, and 105 kph), if obtainable.

At each speed, move the throttle from the road-load vacuum/pressure to the detent or torque converter declutch position described below. This throttle maneuver should be accomplished in about three seconds, and is called fanning.

1. For naturally aspirated vehicles, one inch Hg (3.3 kPa) above:

   a. detent vacuum for automatic transmissions without converter clutches;

   b. the minimum vacuum at which the converter clutch disengages for so-equipped automatic transmissions.

2. For turbocharged vehicles, one inch Hg or 0.5 psig (3.3 kPa) below:

   a. maximum boost at detent for automatic transmissions without converter clutches;

   b. maximum boost or 0.5 psig (3.3 kPa) above the minimum vacuum at which the converter clutch disengages for so-equipped automatic transmissions.

If knocking occurs within any of the vacuum/pressure ranges, establish the manifold vacuum/pressure which gives maximum knock intensity. This is the critical vacuum/pressure to be used for all subsequent constant-vacuum/pressure part-throttle accelerations.

The critical part-throttle vacuum/pressure may be different for other fuel series and must be investigated for each series.

If knock is encountered during the fanning procedure but not during the constant-vacuum/pressure part-throttle accelerations, it should be recorded as tip-in.

Use of vehicle brakes must be avoided

VIII. TEST PROCEDURE

A. Fuel Changeover

To eliminate contamination of the new fuel with residual amounts of the previous fuel, fuel-injected systems should be flushed once with the new fuel and carbureted systems should be flushed twice. Fuel-handling procedures for vehicles equipped with fuel injection systems are explained in Appendix A.

Make one full throttle acceleration after the fuel change.

B. Determination of Knock Intensity

Spark knock is the noise associated with the autoignition* of a portion of the fuel-air mixture ahead of the advancing flame front. It is recurrent and repeatable in terms of audibility and fuel octane quality. This includes knock occurring when going from road load to other operating conditions (e.g., tip-in, etc.)

---

*Autoignition: The spontaneous ignition and the resulting very rapid reaction of a portion or all of the fuel-air mixture. The flame speed is many, many times greater than that which follows normal spark ignition. There is no time reference for autoignition.

Borderline knock is spark knock of lowest audible intensity of at least three pings, and over a range of engine speed of 50 rpm or more, all being repeatable during subsequent accelerations and being sensitive to fuel octane.

No knock means either no audible knock or knock less than borderline intensity.

Above-borderline knock means spark knock of greater audible intensity (louder) than borderline and sensitive to fuel octane quality. There is no restriction on number of pings.

Knock-in is the rpm at which knock is first encountered. Knock-out is the rpm at which knock is last encountered.

Maximum octane requirements will be established by evaluating the occurrence of knock in terms of knock intensity: "N" for none, "B" for borderline, and "A" for above borderline. Establishment of representative knock intensity for a given fuel will be accomplished with a maximum of three (3) rated accelerations. Coastdown time between the end of one acceleration and the beginning of the next should be consistent and a minimum of twenty (20) seconds. As defined below, the first two duplicating accelerations are *sufficient* with "N" and "B" intensity.

"A" knock intensity must not be maintained during an acceleration. If "A" knock intensity occurs, back off the throttle from detent, maintaining "B" level knock by approaching the detent curve as knock fades. Do not duplicate this acceleration. Testing will continue with a higher octane number fuel in that series.

Maximum Octane Number Requirement Determination

Acceleration Number 1	2	3	Representative Rating
N	N	-	N
N	B	N	N
N	B	B	B
B	N	B	B
B	B	-	B
B	A	-	A
A	-	-	A

C. Tank Fuel

Knock on tank fuel is determined for those ONRS vehicles which have a completed owner's questionnaire. Investigate for full-throttle and part-throttle knock in each of the gears or gear/converter clutch combinations shown in the transmission characteristics table in Section VII A and B. Record knock intensity, engine speed, and manifold vacuum/pressure at each operating condition.

D. FBRSU, PR, and FBRUM Fuel Series

The test procedures used for the FBRSU, PR, and FBRUM fuel series are the same, although the FBRU series is tested after FBRSU and before PR. The FBRUM fuel series is tested last. Knock is investigated in all fuel series in each of the gears or gear/converter clutch combinations shown in the transmission characteristics table in Section VII A and B.

Estimate which fuel will be just clear of borderline knock. For the FBRSU series, this estimate is based on tank fuel information, while for the PR series, it is based on data from the FBRSU and FBRU series. The steps in determining the octane requirement of the vehicle on these fuel series include several decision points and are illustrated on page 30 in a flow sheet.

E. FBRU Series

Based on the results of tests on the FBRSU series, estimate which fuel will be just clear of borderline knock. The flow sheet which gives the steps for octane rating a vehicle on FBRU series begins on page 32. Testing on the FBRU series is more extensive than testing on FBRSU, PR, or FBRUM series. If the vehicle is full-throttle limited, part-throttle conditions are investigated up to four octane numbers below the full-throttle requirement.

IX. DATA SUMMARY

A. Raw Data Entry

The purpose of the raw data record is to allow anyone familiar with the rating procedure to independently determine the actual test performed. The original data will be recorded on Form ONRS-MY, Sides C and D, which is the first and permanent record of the results of the rating. This means that data sheets must not be rewritten or typed. In case an error is made, draw a line through the error. Do not erase. All fuels tested must be recorded on Sides C and D whether or not knock is encountered.

B. <u>Vehicle and Test Condition Data</u>

Vehicle and test condition data are recorded on Form ONRS-MY, Side A. Many of the data required are further explained in the footnotes on Side D. Care should be taken to record data in the units printed on the form or using the codes on the form and explained in the footnotes. Special care should be taken to record the VIN correctly, because this information is crucial to properly assigning the vehicle to the correct Survey vehicle code.

If knock is encountered on tank fuel in more than one throttle and/or gear position, the knocking condition to record is the condition of most intense knock. If maximum- and part-throttle knock are of equal intensity, record the part-throttle condition. If two or more gear/torque converter conditions knock with equal intensity, record the highest gear/torque converter condition. If no knock are encountered, no further data are recorded.

C. <u>Octane Number Requirement Summary</u>

The octane number requirement summary block is on the bottom part of Form ONRS-MY, Side A. The data in this block are derived from the original data on Sides C and D. The summary block provides space for both maximum-throttle and part-throttle requirements for the maximum octane requirement for all vehicles. If both maximum-throttle and part-throttle requirements have been found, record both.

Use proper letter designations (see the footnotes on the data sheet) to designate: (1) requirements outside of the reference fuel limits; (2) FBRU part-throttle requirement more than four numbers below maximum; and (3) all other cases for which the octane number requirement has not been determined. Note that in the case of a converter-clutch-equipped vehicle, test gear numbers should indicate whether the converter clutch was locked or unlocked. This should be done for all gears. Note also that in the case of turbocharged or supercharged vehicles, a manifold pressure above atmospheric is indicated as a <u>negative</u> number in units of psig.

When deriving summary data from the raw data, the following guidelines shall be used.

1. If the knock intensity of the highest reference fuel giving knock is borderline, the requirement shall be reported as the octane number of that fuel.

2. If the knock intensity of the highest fuel giving knock is above borderline, the requirement shall be reported as the mid-point between the octane number of the fuel giving knock and that of the next higher fuel.

3. If the octane number requirement in high gear is equal to the requirement in a lower gear, report the highest gear data. Locked condition is higher than unlocked.

4. For part-throttle requirements, report the data from the critical manifold vacuum/pressure observations.

X. GLOSSARY TERMS

A	=	Above-Borderline Knock (see Section VIII B)
B	=	Borderline Knock (see Section VIII B)
BTDC	=	Before Top Dead Center
Critical Manifold Vacuum/Pressure	=	the manifold vacuum/pressure which gives maximum knock intensity during a P/T acceleration (see Section VII)
Detent	=	Throttle position at any speed which is at the point of incipient downshift. (see Section VI)
EGR Valve	=	Exhaust Gas Recirculation Valve
FBRU	=	Full-Boiling Range Unleaded Average Sensitivity Fuel (see Section V)
FBRSU	=	Full-Boiling Range Unleaded High Sensitivity Fuel (see Section V)
FBRUM	=	Full-Boiling Range Unleaded Average Sensitivity (FBRU) Fuel with 15 volume percent MTBE splash-blended into it (see Section V).
F/T	=	Full-Throttle (see Section VII A)
Gr/lb	=	Grains of water per pound of air
GVW	=	Gross Vehicle Weight
Hg	=	Mercury
kg	=	kilogram
Km	=	Kilometers
Knock-In	=	the rpm at which knock is first encountered (see Section VIII B)
Knock-Out	=	the rpm at which knock is last encountered (see Section VIII B)
kPa	=	kilo Paschal
kph	=	kilometers per hour

lb = pound

MAX = Maximum

Maximum Requirement/Maximum Octane Number Requirement = the highest octane number fuel in a fuel series which causes borderline knock in at least one engine condition (see Section II A)

MON = Motor Octane Number

mph = miles per hour

N = No Knock (see Section VIII B)

ON = Octane Number

PCV Valve = Positive Crankcase Ventilation Valve

PFI = Port Fuel Injection

PR = Primary Reference Fuel (see Section V)

psig = pounds per square inch gauge

P/T = Part-Throttle (see Section VII A)

RON = Research Octane Number

RPM = Revolutions per minute

TBI = Throttle-Body Fuel Injection

TC = Torque Converter

TDC = Top Dead Center

DEFINITIONS AND DESCRIPTIONS FOR OCTANE TEST PROCEDURE GUIDE

A = Above Borderline Knock

B = Borderline Knock

N = No Knock

ON = Octane Number

F/T = Full Throttle

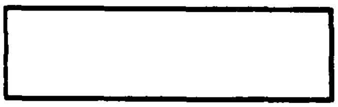
P/T = Part Throttle

Gear/TC = Gear/Torque Converter

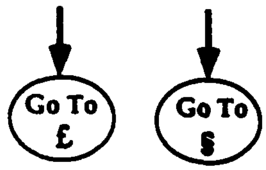
or

= Decision Point

or



= Operation



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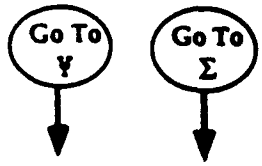
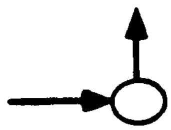


= Entry Point On New Page

= Pathway

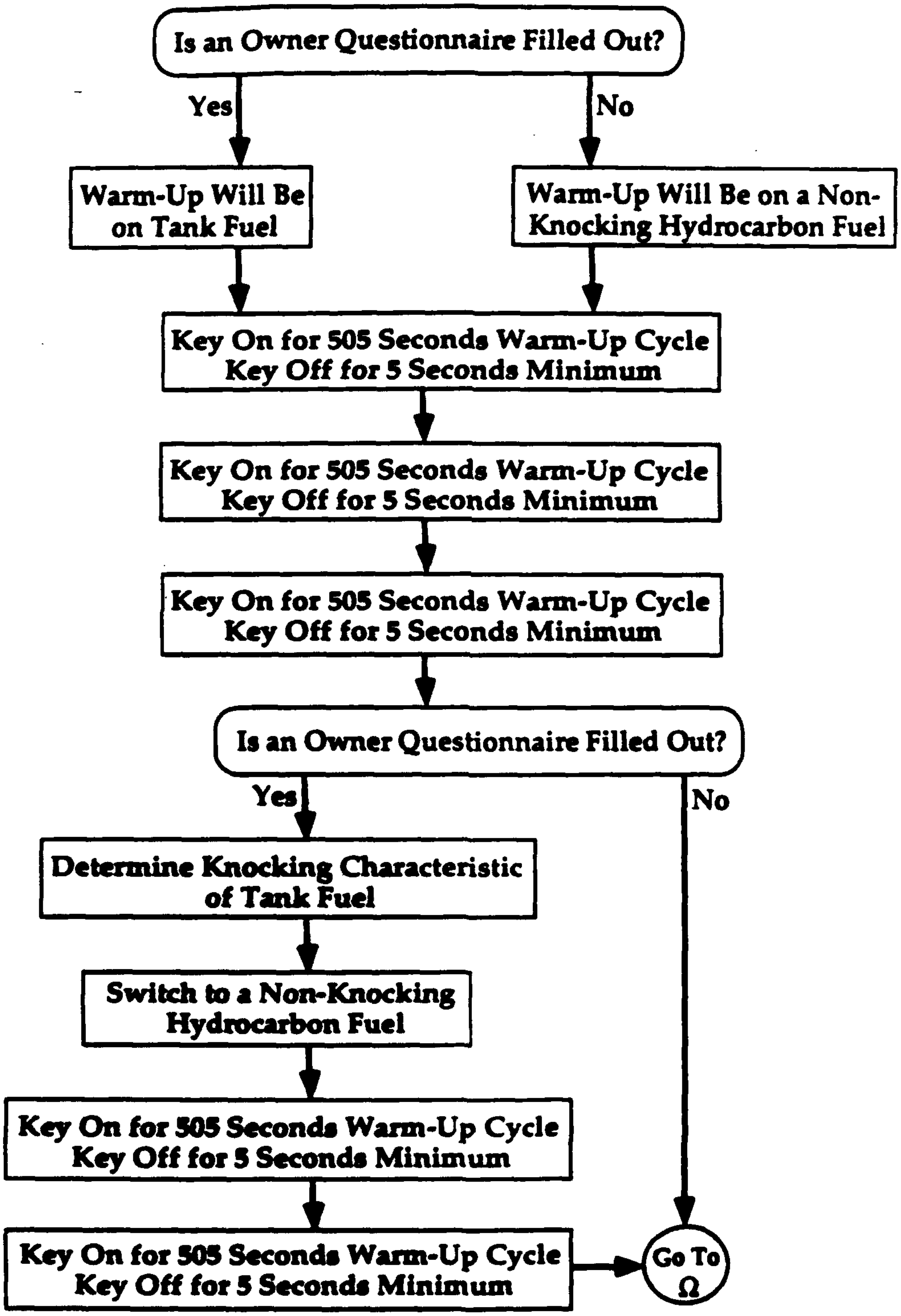
= Go To Another Point

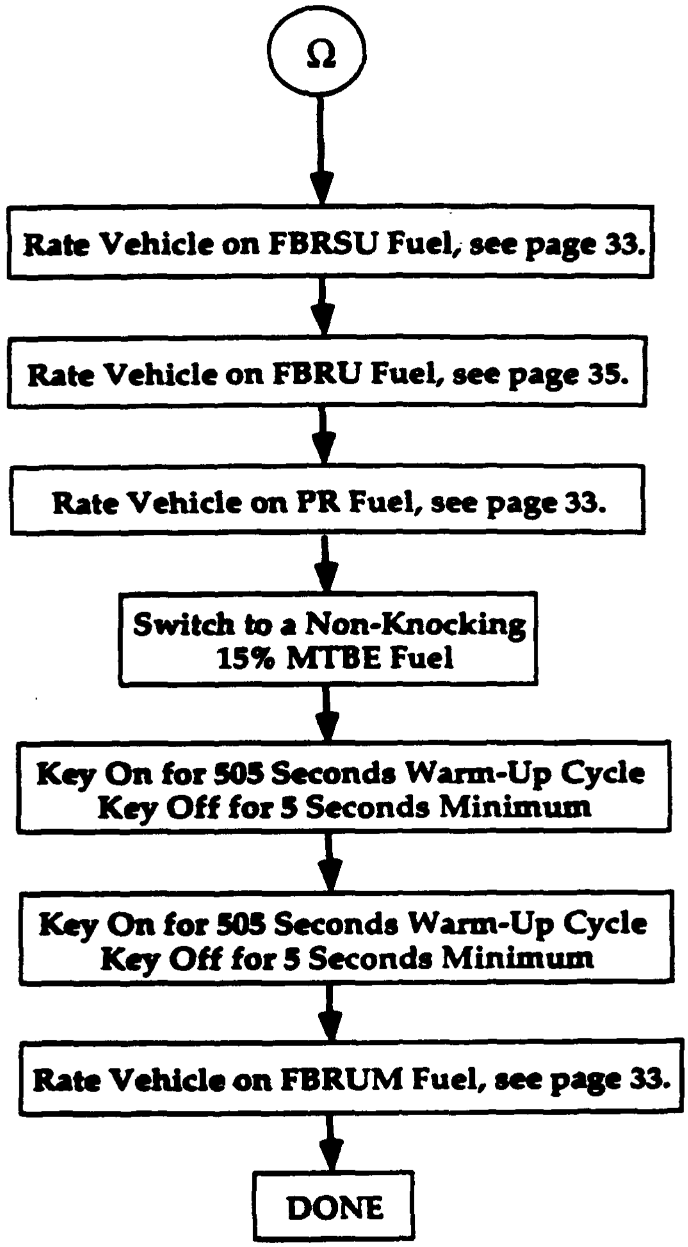


= Entry Point

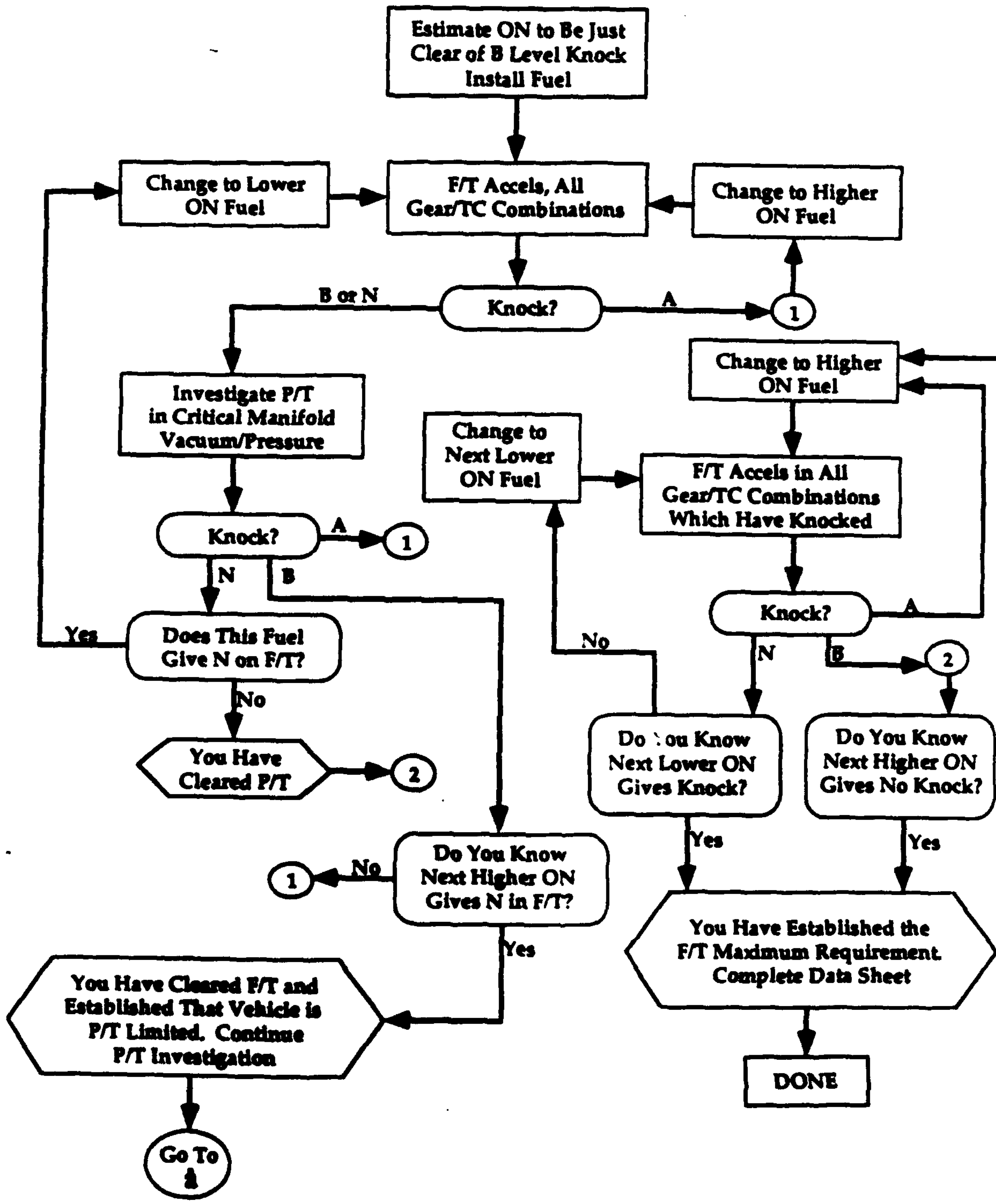
= Completed Segment

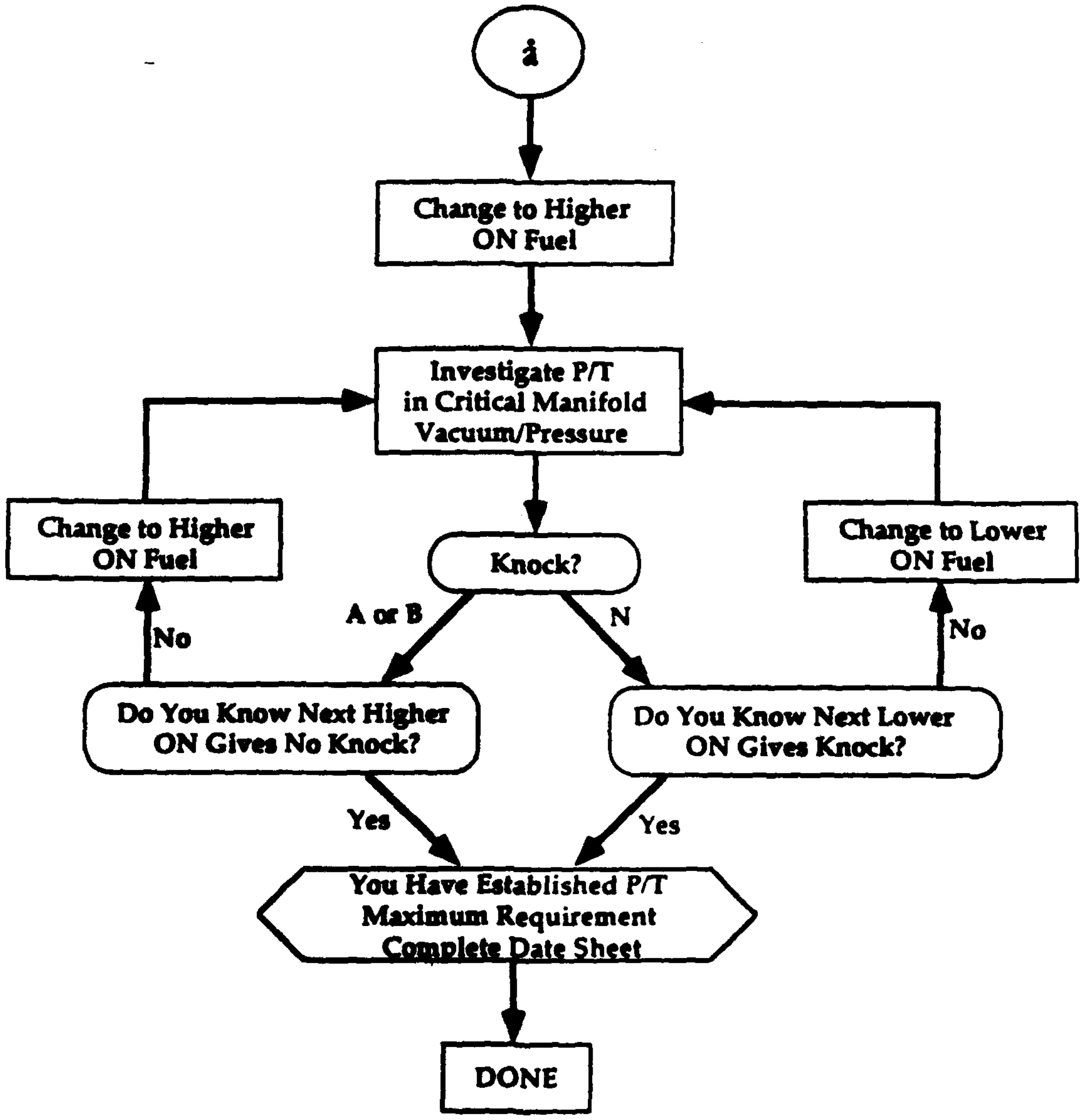
TEST PROCEDURE OVERVIEW



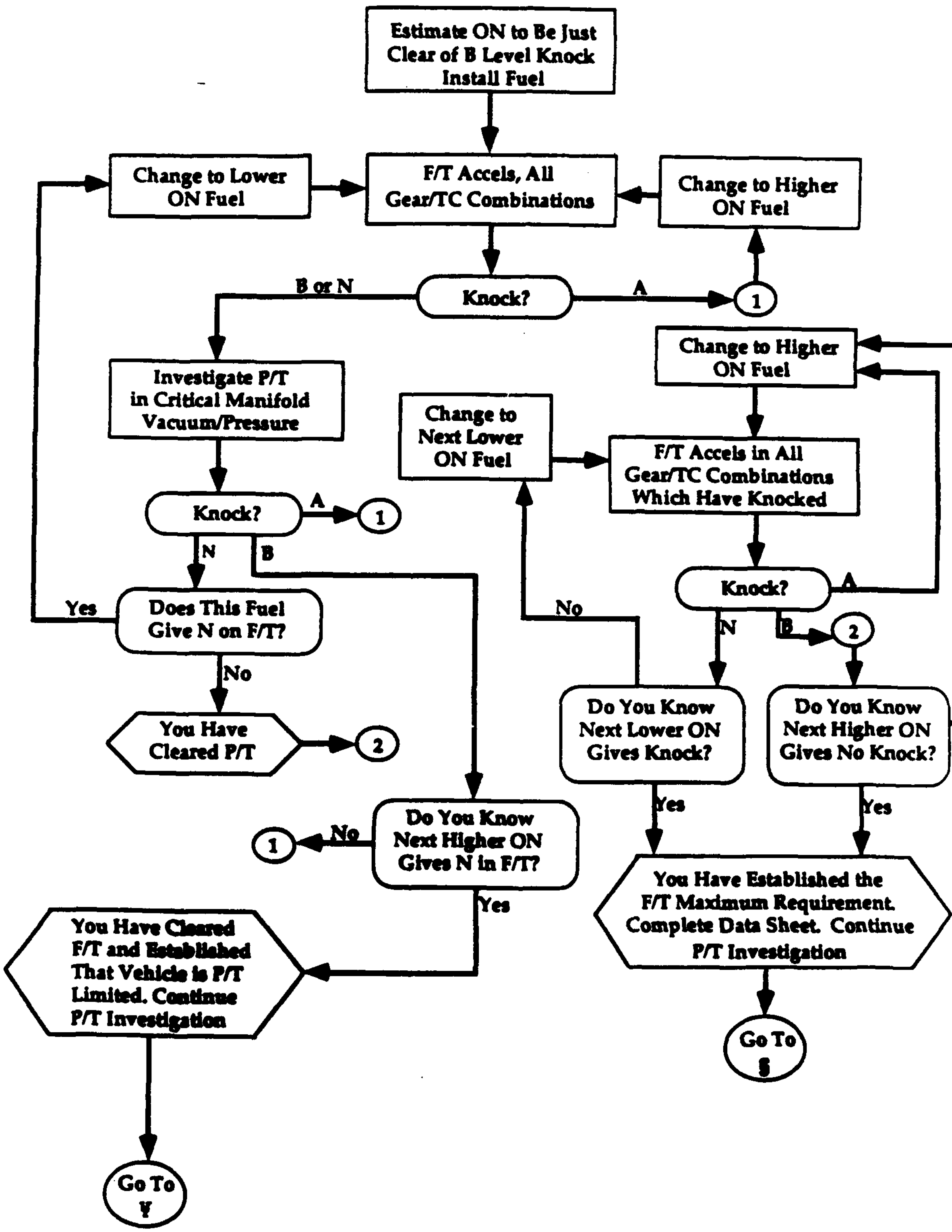

Ω
Rate Vehicle on FBRSU Fuel, see page 33.
Rate Vehicle on FBRU Fuel, see page 35.
Rate Vehicle on PR Fuel, see page 33.
Switch to a Non-Knocking 15% MTBE Fuel
Key On for 505 Seconds Warm-Up Cycle Key Off for 5 Seconds Minimum
Key On for 505 Seconds Warm-Up Cycle Key Off for 5 Seconds Minimum
Rate Vehicle on FBRUM Fuel, see page 33.
DONE

OCTANE TEST PROCEDURE GUIDE FOR FBRSU, PR, AND FBRUM FUEL SERIES

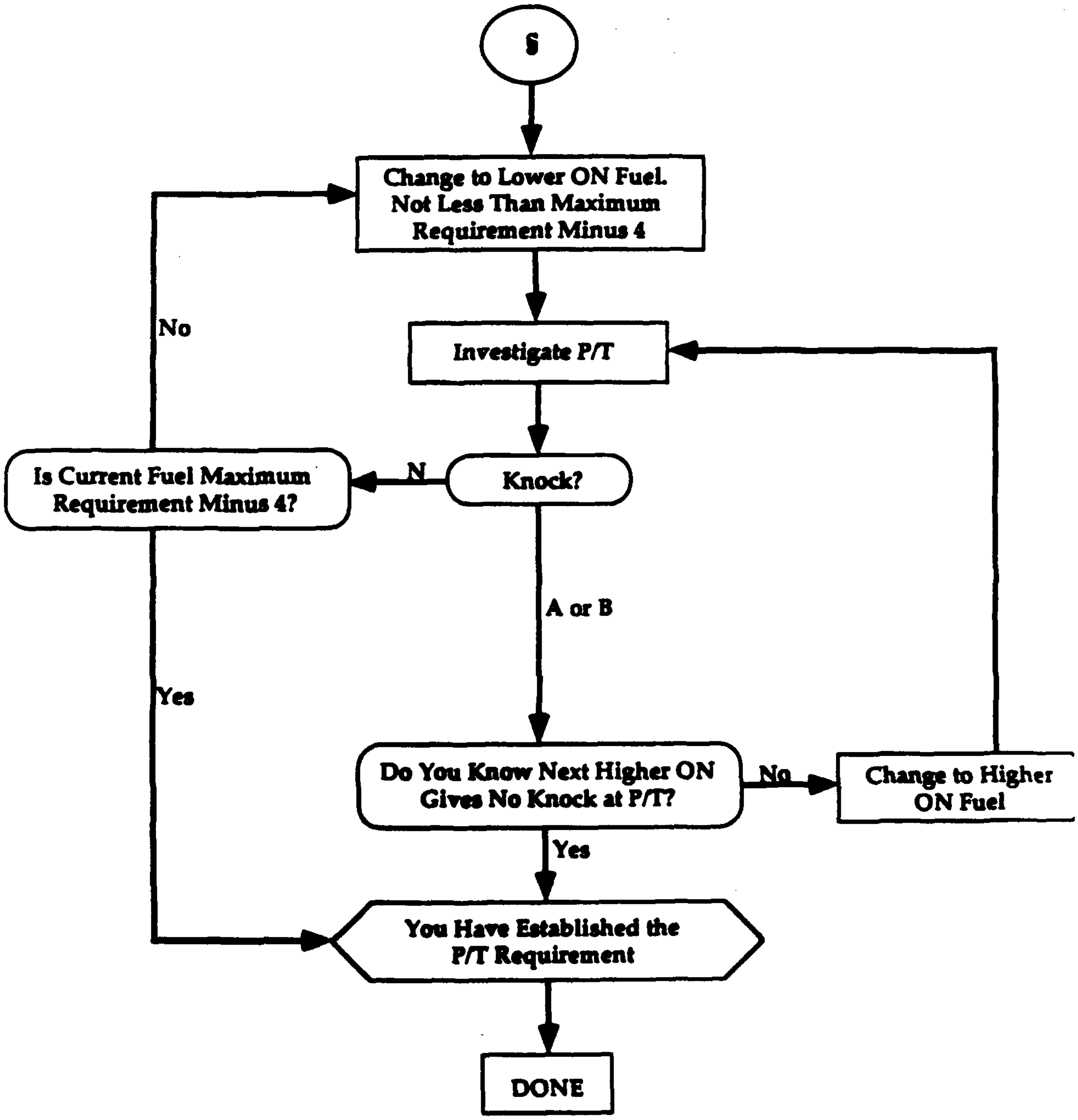



a
Change to Higher ON Fuel
Investigate P/T in Critical Manifold Vacuum/Pressure
Change to Higher ON Fuel
Knock?
Change to Lower ON Fuel
A or B
N
No
No
Do You Know Next Higher ON Gives No Knock?
Do You Know Next Lower ON Gives Knock?
Yes
Yes
You Have Established P/T Maximum Requirement Complete Date Sheet
DONE

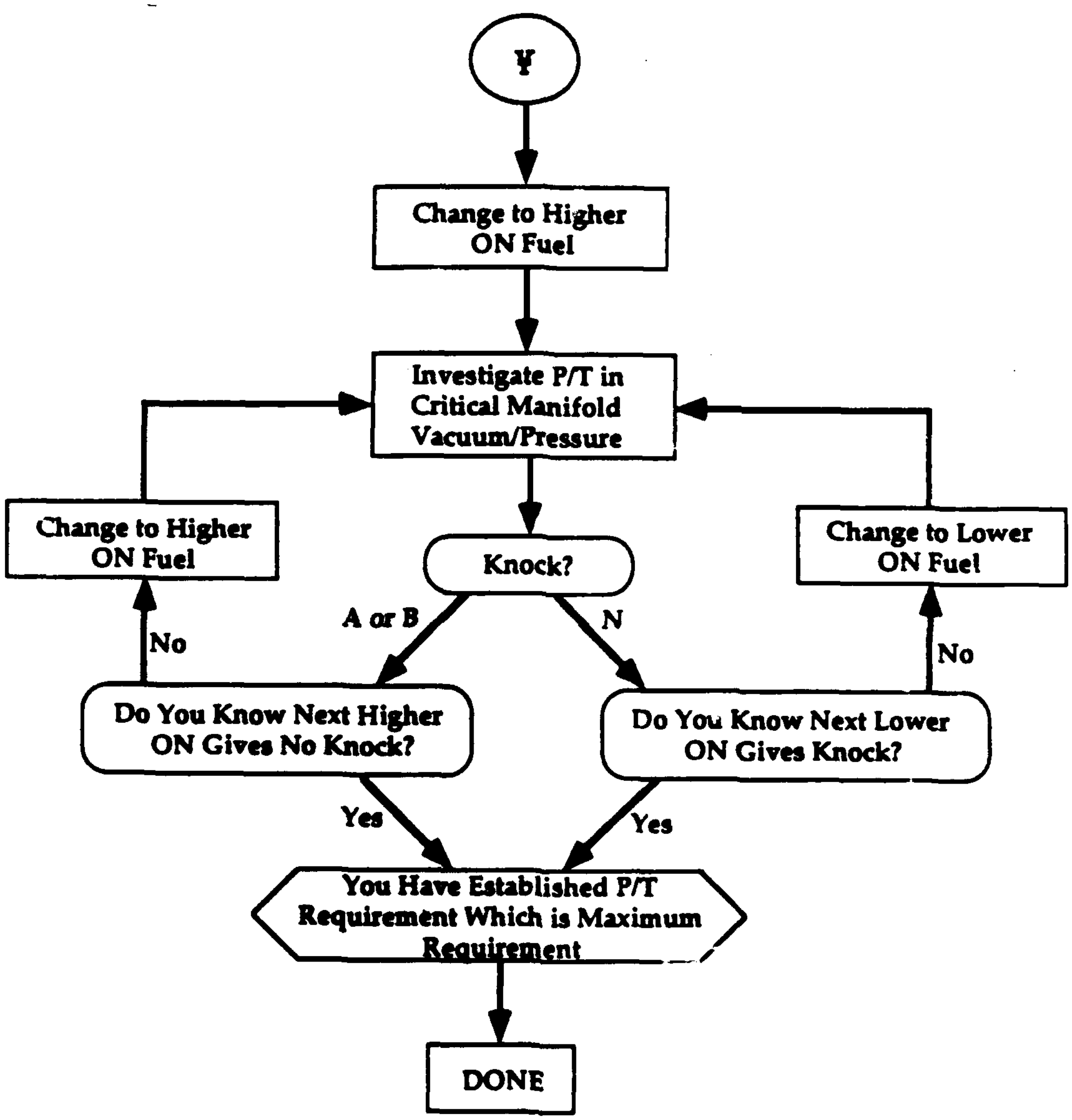
OCTANE TEST PROCEDURE GUIDE FOR FBRU FUEL SERIES



P/T Investigation For Vehicles With Maximum Requirement at F/T



Investigation of Maximum Requirement at P/T for P/T Limited Vehicles



ONRS-91
Side A

1991 CRC OCTANE NUMBER REQUIREMENT SURVEY - 1991 MODEL VEHICLES

Sheet ___ of ___

Company: ______________ Date: ______________ Test Location (R/C): ______________ (1)*

Primary Contact: ______________ Phone: (____) ______________

Driver: ______________ Observer: ______________

TO BE FILLED IN BY CRC: Observ. No.: _____-_____ Veh. Code: ________ VIN Digit: ____ Owner: _____

VEHICLE DATA

Vehicle Make: ______________ Model: ______________

Engine Type: ________ (2)* V.I.N.: |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|

Engine Calibration (Ford): ______________ License No.: ______________

Knock Sensor (Y/N): ______ Emission Certification (F/C/A/B/E): ______ (3) Induction (T/S): ______ (4)

Carburetion (P/T/1..4): __ (5) Displacement (Liters): _____._____ Compression Ratio: _____._____

Transmission (A/M): ______ (6) No. of Speeds: ______ (7) Converter Clutch (Y/N): ________

Spark Advance (Degrees BTDC) (8): As Received: __________ As Tested: __________

Air Conditioning (Y/N): ______ Odometer (Miles): ______________

WEATHER Ambient Temperature (°F): ______ Barometer ("Hg): ____.____ Humidity (Gr/Lb): ______

VEHICLE SOURCE Owner-Operated: _____ Rental: _____ Other: ______________

TANK FUEL DATA Customer Knock (Y/N/O): ______ (9) Research Octane No.: _____.__ Motor Octane No. _____.__

Knock Intensity (N/B/A): ______ (10) Throttle (M/P): ______ (11) Test Gear No.: ______

RPM @ Max. Knock Intensity: ______ Man. Vac. ("Hg/psig): ____.____ (13)

OCTANE NUMBER REQUIREMENT SUMMARY

MAXIMUM REQUIREMENTS

Ref Test Fuel	Research Oct. No. (15)	Test Gear (12)	RPM @ Max. Knock	Manifold Vacuum ("Hg/psig) (13)	Research Oct. No. (15)	Test Gear (12)	RPM @ Max Knock	Manifold Vacuum ("Hg/psig) (13)
	Maximum-Throttle Requirement				Part-Throttle Requirement			
FBRSU	___.__	___	___	___.__	___.__	___	___	___.__
FBRU	___.__	___	___	___.__	___.__	___	___	___.__
PR	___.__	___	___	___.__	___.__	___	___	___.__
FBRUM	___.__	___	___	___.__	___.__	___	___	___.__

Side B

TRANSMISSION DOWNSHIFT CHARACTERISTICS

4th Locked Overdrive			4th Gear			3rd Locked		
mph	Man. Vac./psig	RPM	mph	Man. Vac./psig	RPM	mph	Man. Vac./psig	RPM

3rd Gear			2nd Locked			2nd Gear		
mph	Man. Vac./psig	RPM	mph	Man. Vac./psig	RPM	mph	Man. Vac./psig	RPM

VEHICLE INSPECTION LIST

____ Vacuum Lines - Good Condition and Appropriately Connected

____ Air Pump Hoses - Good Condition and Appropriately Connected

____ PCV Valve Functioning

____ EGR Valve - Functioning

____ Heated Inlet Air - Functioning

____ Anti-dieseling solenoid - Functioning and adjusted properly

____ Tire pressure

____ Crankcase Oil Level

____ Coolant Level

____ Automatic Transmission Fluid Level

____ Charge Indicator Light or Fluid Level of Battery

____ Carbureted Engines - Plug Fuel Return Line if present

____ Disconnect Fuel Tank Vent Line at Vacuum Canister

____ Check Fault Codes

Sheet___of___Sheets

1991 CRC OCTANE NUMBER REQUIREMENT SURVEY - 1991 MODEL VEHICLES
CONTINUATION SHEET

Company: ____________________ Date: ____________________

Vehicle Make: ____________________ Model: ____________________

V.I.N.: ____________________ License No.: ____________________

TO BE FILLED IN BY CRC: Observation No.:____-____

Reference Fuel		Test Gear No. (12)	Throttle Position (16)	Man. Vac. Hg/psig (13)	Max. Knock Intensity (10)			(10)	Speed Range, RPM		RPM of Max. of Intensity
					Acceleration						
Series	Res. O.N.				1	2	3	Final Rating	Knock In	Knock Out	

Side D

Reference Fuel		Test Gear No. (12)	Throttle Position (16)	Man. Vac. Hg/psig (13)	Max. Knock Intensity (10)			(10)	Speed Range, RPM		RPM of Max. of Intensity
Series	Res. O.N.				Acceleration			Final Rating	Knock In	Knock Out	
					1	2	3				

LEGEND

(1) R = Road; C = Chassis Dynamometer
(2) e.g. V8, L4, R for Rotary
(3) F = Federal; C = California;
A = Altitude; B = "C" and "A"
E = Everything
(4) T = Turbocharged; S = Supercharged
(5) Number of Carb. Venturis or T for throttle body injection or P for port injection
(6) A = Automatic; M = Manual
(7) Record number of transmission speeds
(8) + = BTDC; - = ATDC
(9) Y = Yes; N = No; O = Objectionable
(10) N = None; B = Borderline; A = Above Borderline
(11) M = Maximum-Throttle;
P = Part-Throttle higher than Maximum-Throttle Requirement
(12) If vehicle is equipped with converter clutch, in addition to gear number, indicate U for unlocked and L for locked (e.g., 3U)
(13) If boost pressure greater than atmospheric, use Manifold Pressure (psig) with minus sign (-); when fanning, write in "FAN"
(14) Applies only to knock-sensor vehicles.
(15) If ONR not bounded by test fuels,
L = Less than lowest available fuel;
H = Higher than highest available fuel.
If part-throttle requirement is greater than four numbers below maximum-throttle requirement, enter F.
If above does not apply and ONR is not determined, enter U.
(16) Record M for Maximum-Throttle, P for Part-Throttle, or FAN if fanning

COMMENTS

APPENDIX A

to the

CRC E-15-91 TECHNIQUE

PROCEDURE FOR SETTING UP VEHICLES

WITH FUEL INJECTION

APPENDIX A

PROCEDURE FOR SETTING UP VEHICLES AND HANDLING REFERENCE FUELS: VEHICLES EQUIPPED WITH FUEL INJECTION

1. To run octane requirements on fuel-injected vehicles, it is necessary to install an external fuel supply line with auxiliary electric fuel pump from the reference fuel can to the vehicle fuel system and an external return line back to the reference fuel can.

2. There are two types of fuel injection systems: throttle-body injection, and multi-port injection. As a general description, the systems will contain the following parts:

   Fuel Tank
   High- or Low-Pressure In-Tank Fuel Pump
   Fuel Supply Line(s)
   In-Line Filter(s)
   High-Pressure Chassis-Mounted Pump (not required for all vehicles)
   Fuel Rail (to supply multiple injectors on port fuel injection)
   Fuel-Pressure Regulator (integral on throttle-body, on fuel rail with multi-port injection; controls pressure at the injectors).

   Depending upon the vehicle's specific fuel system and/or tester's preference, installation of the required auxiliary equipment can be accomplished in a variety of ways.

3. The auxiliary fuel supply line may be installed anywhere between the fuel tank and the inlet at the throttle-body or fuel rail. The auxiliary fuel return line may be installed anywhere between the fuel-pressure regulator outlet and the tank.

4. After connections have been broken, the fuel lines on the fuel tank side should be capped and the vehicle's pump(s) disconnected or disarmed. Alternately, an additional fuel line can be looped between the supply and return lines and the vehicle pump(s) allowed to circulate fuel directly back to the fuel tank. Caution should be exercised if this alternate technique is used. A high pressure will build up in the tank due to the large amount of vapors generated.

The auxiliary fuel supply system must be capable of supplying fuel at a pressure slightly higher than the maximum fuel pressure required (at wide-open-throttle on normally aspirated engines or at maximum manifold boost pressure on turbocharged or supercharged engines) by the particular vehicle being tested. This is to overcome any line losses and thus insure accurate results. This may be accomplished by using an adjustable high-pressure pump, or by using a low-pressure pump to supply fuel to the chassis-mounted high-pressure pump if the testing lab chooses to keep it in the system. A fuel filter may be required between the auxiliary pump and the reference fuel can to protect the pump. The fuel return line should be connected to a tee at the auxiliary pump inlet. The reference fuel can should be vented to outside the vehicle.

It is possible to use three-way valves in the fuel line between the fuel pump and the fuel tank and between the return line and the fuel tank. When used, the operator must change the return line valve to the auxiliary fuel system while the engine is shut down, to avoid building up excessive pressure in the return line which could damage both the fuel-pressure regulator and injection pump.

5. When changing from one reference fuel can to another, the following steps should be followed:

   a. Disconnect fuel inlet line from reference fuel can and run engine a short time; <u>do not run out of fuel</u> since this will introduce air into the fuel injection system and excessive cranking will be required to restart the engine.

   b. With the engine shut off, disconnect the fuel return line from the auxiliary pump inlet and connect it to a slop can. Connect the fuel supply line to the new reference fuel can and run the engine long enough to purge the old reference fuel from the system. The time required will be dependent upon length of added fuel lines, but it will be approximately 30-60 seconds; approximately 1-2 quarts of fuel will be discarded to slop.[1]

   c. With the engine off, connect the fuel return line to the auxiliary pump inlet. The vehicle is then ready to be tested.

   d. When changing to the next reference fuel, it is necessary to repeat Steps a, b, and c.

---

(1) It is critical to circulate an adequate amount of fuel to the slop can to prevent reference fuel contamination.

CAUTION

Fuel supply lines remain pressurized long after the engine is shut off; be sure to relieve the pressure before disconnecting fuel lines.

Use fuel lines designed for high pressure. They should be rated for at least 250 psi working pressure and for 1000 psi burst pressure.

The engine and auxiliary fuel pumps should be shut off while changing from auxiliary to tank fuels.

Purging procedures should be followed strictly to preclude reference fuel contamination or discarding more fuel than is required.

Vehicle pump(s) may be disarmed by use of the inertia switch if so equipped. The voltage supplied to the inertia switch may then be used to power the auxiliary pump. When making these electrical connections, do not "splice" into the wire; instead, connect the wire lead to the connector.

Do not disarm the vehicle fuel pump by removing the fuse, since other accessories may be connected to the same circuit; instead, disconnect the fuel pump electrical lead.

Auxiliary fuel return lines should be of a size larger enough to prevent a build-up of back pressure which could prevent the proper operation of the pressure regulator.

Use of the "rolled edge" style hose clamps, such as those made by Chrysler, is recommended to prevent damage to fuel lines.

Note: Diagnostic scanners should not be used while knock testing.

APPENDIX E

1991 OCTANE NUMBER REQUIREMENT SURVEY DATA

GLOSSARY

(For Appendix E Only)

Vehicle Type (TYPE):	C Passenger car T Light-duty truck or van
Emission Certification (EMCT):	A Altitude B "C" and "A" C California F Federal E Everything
Knock Sensor (KS):	Y Yes N No
F/A System (F/A SYS):	If single character: T Throttle-body fuel injection P Multiple-port fuel injection # Carburetor where # is no. venturi If two characters, second character is as above, and first character is: T Turbo S Supercharger
Displacement (DSP):	Engine Displacement in liters
Transmission (TRANS):	First character: M Manual shift A Automatic shift Second character is number of forward gears
Air Conditioner (AIR):	Y Yes N No
Spark Advance:	+ Before Top Center - After Top Center
Test Fuel:	1 Tank Fuel 2 FBRSU 3 FBRU 4 PR 5 FBRUM

Octane Number Requirements: (expressed as Research ON)	L	Less than lowest available ON for FBRU, FBRSU, and FBRUM fuels and less than 76 for PR fuels
	H	Higher than highest available ON for FBRU, FBRSU, and FBRUM fuels and higher than 100 ON for PR fuels
	F	Part-throttle requirement greater than four numbers below maximum-throttle requirement
Throttle (THR):	M	Maximum
	P	Part
Gear:	1-6	Manual and Automatic
	L	Tested in lockup (torque converter engaged)
Manifold Vacuum (VAC):	Inches Hg,	positive for vacuum, negative (-) for pressure
Owner-Reported Knock (OWKNK):	Y	Yes, Not Objectionable
	O	Objectionable
	N	No
Rater-Reported Noise Intensity (KNINT)	N	None
	B	Borderline
	A	Above Borderline

1991 CRC OCTANE NUMBER REQUIREMENT SURVEY

OBS. NO.	VEHICLE DESCRIPTION TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE AS RCD	SPARK ADVANCE AS TST	ODOM MILES	WEATHER AMB TMP	BAROM	HUM	FUEL	MAXIMUM OCT NO	MAXIMUM GEAR	MAXIMUM RPM	MAXIMUM VAC	PART-THROTTLE OCT NO	PART-THROTTLE GEAR	PART-THROTTLE RPM	PART-THROTTLE VAC	TANK FUEL OWKNK	OCT NO RES	OCT NO MOTR	RATER KNINT	THR	GEAR	RPM	VAC
05-30	C	F	N	T	1.0	A3	9.5	Y	+ 6	+ 6	10072	70	30.00	27	3	88.0	3	3000	0.5	F											
															2	89.0	3	2900	0.5												
															4	87.0	3	3000	0.5												
															5	85.0	3	2800	0.5												
41-26	C	C	N	P	1.3	A3	9.7	N			13891	67	30.06	68	3	90.0	3	2200	2.0	88.0	3	2300	6.0								
															2	91.0	3	2800	2.0												
															4	87.0	3	2650	2.0												
															5	86.0	3	2600	2.0	86.0	3	2350	5.0								
47-15	C	C	N	T	1.5	M5	9.2	Y	+18	+18	24918	70	30.02	50	3	92.0	4	2500	1.0	91.0	4	3250	2.0								
															2	94.0	4	4000	1.0												
															4	90.0	4	1750	1.0												
															5	89.0	4	1700	1.0												
05-16	C	F	N	T	1.5	M5	9.2	Y			10150	70	29.70	24	3	89.0	4	2000	0.5	F				N	97.5	87.5	N				
															2	90.0	4	2300	0.5												
															4	88.0	4	2200	0.5												
															5	88.0	4	2500	0.5												
07-05	C	F	N	T	1.5	A4	9.2	Y	+18	+18	19307	70	30.06	0	3	88.0	3U	3200	0.0					N			A	M	3U	3300	0.0
															2	90.0	3U	3400	0.0												
															4	88.0	2U	4200	0.0												
															5	87.0	3U	3100	0.0												
41-24	C	C	N	T	1.5	A4	9.2	Y	+18	+18	10850	68	30.60	68	3	90.0	2U	3000	1.2	F											
															2	93.0	2U	3200	1.2												
															4	87.0	4U	2850	0.8												
															5	85.0	4U	2900	0.8												
47-17	C	C	N	T	1.5	M5	9.2	Y	+18	+18	8140	70	30.15	50	3	94.0	4	3600	0.5	100.0	4	3650	4.0								
															2	97.0	4	3600	0.5												
															4	92.0	4	1750	0.5												
															5	92.0	4	3500	0.5												
41-08	C	C	N	P	1.5	M5	9.4	Y	+ 5	+5	6338	61	30.06	51	3	M	3		0.2	103.0	3	2600	2.7	N			B	M	4	2550	0.2
															2	M	3	2600	0.2	103.0	3	2550	2.6								
															4	M	3	2450	0.2	100.0	3	2650	2.4								
															5	M	3	2250	0.2	105.0	3	2500	2.8								
60-02	C	F	N	P	1.5	M5	9.3	N	+10	+10	6017	72	29.42	41	3	89.0	4	1650	0.0	85.0	4	1600	2.0								
															2	90.0	4	1650	0.0												
															4																
															5	89.0	4	1650	0.0												
05-17	C	F	N	P	1.5	A3	9.3	Y	+ 3	+ 3	24777	70	29.30	28	3	91.0	2U	3550	0.5	F				N	97.7	87.9	N				
															2	91.0	2U	3650	0.5												
															4	89.0	2U	3500	0.5												
															5	89.0	2U	3700	0.5												
08-13	C	F	N	T	1.6	A3	9.5	Y	+10	+10	13199	73	30.05	52	3	93.0	3U	2650	0.5	93.0	3U	2600	2.0								
															2	92.0	3L	2550	0.5	94.0	3U	2600	2.0								
															4	90.0	3U	2650	0.5												
															5	93.0	3U	2600	0.5	93.0	3U	2550	2.0								

1991 CRC OCTANE NUMBER REQUIREMENT SURVEY

VEHICLE DESCRIPTION												WEATHER			OCTANE NUMBER REQUIREMENT DATA									TANK FUEL INFORMATION							
																MAXIMUM				PART-THROTTLE							RATER				
OBS. NO.	TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE AS RCD	SPARK ADVANCE AS TST	ODOM MILES	AMB TMP	BAROM	HUM	FUEL	OCT NO	GEAR	RPM	VAC	OCT NO	GEAR	RPM	VAC	OWKNK	OCT NO RES	OCT NO MOTR	KNINT	THR	GEAR	RPM	VAC
47-07	C	C	N	T	1.6	A4	9.1	Y	+10	+10	13167	70	30.09	50	3	88.0	3L	2500	0.6	88.0	3L	2500	2.2	N			N				
															2	89.0	3L	2500	0.6												
															4	88.0	3L	2500	0.6												
															5	87.0	3L	2500	0.6												
23-14	C	F	N	T	1.6	M5	8.6	Y	+10	+10	7984	46	28.71	24	3	92.0	4	1400	0.5	90.0	4	1500	1.5								
															2	92.0	4	1500	0.5	92.0	4	1500	1.5								
															4	91.0	4	1800	0.5												
															5	90.0	4	1500	0.5	90.0	4	1450	1.5								
08-15	C	F	N	T	1.6	A3	8.6	Y	+10	+10	11236	77	30.23	74	3	88.0	3L	2750	0.8	84.0	3U	2450	2.0								
															2	90.0	3L	2550	0.8												
															4	84.0	3L	2700	0.8												
															5	87.0	3L	2600	0.8												
08-26	C	F	N	T	1.6	A3	8.6	Y	+10	+10	10770	75	29.85	58	3	85.0	2U	3050	0.7	82.0	3U	2300	2.5								
															2	86.0	3U	3100	1.0												
															4	84.0	2U	3200	0.7												
															5	L				L											
29-05	C	F	N	P	1.6	A4	9.3	Y	+ 7	+ 7	13336	74	29.38	70	3	86.0	3L	1800	1.0	85.0	3L	1800	4.0								
															2	86.0	3L	1800	1.0												
															4	86.0	3L	1800	1.0												
															5	86.0	3L	1800	1.0												
47-05	C	C	N	P	1.6	M5	9.4	Y	+10	+10	19400	70	30.03	50	3	92.0	4	4400	0.5	90.0	4	4450	1.5	N			N				
															2	94.0	4	4350	0.5												
															4	91.0	4	1500	0.5												
															5	89.0	4	4400	0.5												
41-19	C	F	N	P	1.6	M5	9.4	Y	+10	+10	18936	70	30.26	57	3	88.0	4	2500	0.4	F											
															2	91.0	3	4600	0.6												
															4	87.0	4	2600	0.4												
															5	90.0	4	2650	0.4												
07-01	C	F	N	P	1.6	A4	9.5	Y	+10	+10	9010	72	30.03	0	3	83.0	3U	3700	1.0					N			N				
															2	84.0	4L	3200	1.0												
															4	84.0	4L	3500	1.0												
															5	L				L											
29-18	C	F	N	P	1.6	A4	9.5	Y	+10	+10	14070	74	29.42	101	3	87.5	3U	2300	0.6	87.0	4L	2300	4.0								
															2					92.0	4L	2300	4.0								
															4	87.0	4L	2400	0.6												
															5	86.5	4L	2400	0.6												
29-17	C	F	N	P	1.6	A4	9.5	Y	+10	+10	14574	75	29.42	99	3					86.0	3U	2300	4.0								
															2					92.0	3U	2100	4.0								
															4	86.0	4L	2300	0.6												
															5	84.5	4L	2200	0.6												
08-03	C	F	N	P	1.6	A3	9.5	Y	+10	+10	20915	78	30.20	48	3	87.0	2U	3000	0.5	86.0	3U	2350	4.0								
															2	89.0	2U	3050	0.5	86.0	3U	2500	4.0								
															4	86.0	2U	3300	0.5												
															5	86.0	3U	2700	0.5												

1991 CRC OCTANE NUMBER REQUIREMENT SURVEY

	VEHICLE DESCRIPTION											WEATHER			OCTANE NUMBER REQUIREMENT DATA									TANK FUEL INFORMAT.							
																MAXIMUM				PART-THROTTLE							RATER				
									SPARK ADVANCE																OCT NO						
OBS. NO.	TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	AS RCD	AS TST	ODOM MILES	AMB TMP	BAROM	HUM	FUEL	OCT NO	GEAR	RPM	VAC	OCT NO	GEAR	RPM	VAC	OWKNK	RES	MOTR	KNINT	THR	GEAR	RPM	VAC
08-17	C	F	N	P	1.6	A3	9.5	Y	+10	+10	20434	70	30.34	57	3	87.0	3U	2750	0.6	86.0	3U	2550	3.0								
															2	88.0	3U	2700	0.6	88.0	3U	2500	3.0								
															4	86.0	3U	2600	0.6												
															5	87.0	3U	2650	0.6												
29-20	C	F	N	P	1.6	A3	9.5	Y	+10	+10	11955	74	29.50	79	3	92.5	3L	2800	0.4	92.0	3L	2600	6.0	N			A	M	3L	2600	0.4
															2					94.5	3L	2500	6.0								
															4	92.0	2U	3000	0.4												
															5	91.0	3L	2000	0.4												
60-01	C	F	N	P	1.6	A3	9.5	Y	+10	+10	22873	88	28.90	52	3	84.0	3U	2700	0.7												
															2	82.0	3L	3200	0.3												
															4																
															5	L				L											
60-03	C	F	N	P	1.6	A3	9.5	Y	+10	+10	21699	82	29.78	32	3	90.0	3U	2800	0.6	88.0	3U	2700	1.0								
															2	91.0	3U	2800	0.6	91.0	3U	2800	1.0								
															4	89.0	2U	3700	0.0												
															5	87.0	3U	2800	0.6												
41-25	C	C	N	P	1.6	A3	9.5	Y	+10	+10	20561	67	30.04	68	3	92.0	3U	2700	0.6	90.0	3U	2400	3.0								
															2	92.0	2U	2850	0.6												
															4	91.0	3U	2700	0.6												
															5	91.0	3U	2700	0.6												
41-16	C	C	N	P	1.6	A4	9.5	Y	+10	+10	16291	70	30.10	61	3	85.0	3U	2600	1.6	86.0	3U	2300	4.0								
															2	86.0	3U	2600	1.6												
															4	84.0	3U	2600	1.6												
															5	85.0	3U	2550	1.6	85.0	3U	2600	4.0								
32-12	C	F	N	P	1.8	M5	9.0	Y	+10	+10	11614	70	29.74	50	3	82.0	4	2100	0.5	82.0	4	2200	2.0	N							
															2	83.0	4	2200	0.5	83.0	4	2200	2.0								
															4	82.0	4	2100	0.5	82.0	4	2100	2.0								
															5	L				L											
28-03	C	F	N	P	1.8	M5	10.0	Y			17230	70	29.76	50	3	93.0	4	1200	0.5	94.0	4	1200	1.5								
															2	93.0	4	1200	0.5	94.0	4	1200	1.5								
															4	95.0	4	1200	0.5												
															5	93.0	4	1200	0.5												
08-30	C	C	N	P	1.8	M5	10.0	Y			10224	70	29.56	44	3	88.0	3	1650	0.5	87.0	4	1800	2.5	N	96.7	85.6	N				
															2	89.0	3	1700	0.5	87.0	4	1800	2.5								
															4	98.0	4	2500	0.5												
															5	86.0	4	1800	0.5												
28-13	C	F	N	P	1.8	M5	8.9	Y	+10	+10	15045	70	29.25	50	3	83.0	3	2300	0.2	80.0	4	2000	1.2								
															2	83.0	3	2400	0.2												
															4	83.0	4	2300	0.2												
															5	L				L											
29-25	C	F	Y	P	1.8	A3	10.0	Y	+10	+10	15798	72		71	3					84.0	3	2500	8.0								
															2					85.0	3	2500	8.0								
															4					81.0	3	2200	8.0								
															5	L				L											

1991 CRC OCTANE NUMBER REQUIREMENT SURVEY

	VEHICLE DESCRIPTION											WEATHER			OCTANE NUMBER REQUIREMENT DATA									TANK FUEL INFORMATION							
																MAXIMUM				PART-THROTTLE							RATER				
									SPARK ADVANCE																OCT NO						
OBS. NO.	TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	AS RCD	AS TST	ODOM MILES	AMB TMP	BAROM	HUM	FUEL	OCT NO	GEAR	RPM	VAC	OCT NO	GEAR	RPM	VAC	OWKNK	RES	MOTR	KNINT	THR	GEAR	RPM	VAC
32-15	C	F	N	P	1.9	M5	9.0	Y	+10	+10	22334	70	29.47	50	3	88.0	3	4100	1.0	88.0	3	4000	2.0	N			8	P	3	4000	2.
															2	89.0	3	3950	1.0	89.0	3	4000	2.0								
															4	88.0	3	4000	1.0	88.0	3	4000	2.0								
															5	87.0	3	4000	1.0	87.0	3	4100	2.0								
28-23	C	F	N	P	1.9	A4	9.0	Y			13830	70	28.93	50	3	88.0	3U	2600	0.8	86.0	4L	1400	2.5								
															2	90.0	3U	2600	0.8												
															4	87.0	4L	1400	2.0												
															5	88.0	3U	2600	0.8												
29-22	C	F	N	P	1.9	A4	9.0	Y	+10	+10	14804	72	29.53	63	3	93.0	2U		1.0	93.0	2U		2.0								
															2	96.5	2U		1.0												
															4	90.0	4L		1.0												
															5	93.0	3U		1.0												
29-24	C	F	N	P	1.9	A4	9.0	Y	+10	+10	14364	72	29.47	61	3	95.0	2U		1.0	95.5	2U		2.0								
															2					99.0	2U		2.0								
															4	90.0	4L		1.2												
															5					96.0	2U		2.0								
47-12	C	C	N	P	1.9	A4	9.0	Y			16891	70	30.25	50	3	94.0	4L	2400	1.0	94.0	4L	1600	5.0	N	92.9	81.8	8	M	4L	2150	[illegible]
															2	95.0	4L	2400	1.0												
															4	93.0	4L	1600	1.0												
															5	91.0	4L	1600	1.0												
05-04	C	F	N	P	1.9	A4	9.0	Y			19675	70	30.02	50	3	87.0	2U	3680	0.7	F											
															2	91.0	2U	3500	0.8												
															4	86.0	2U	3300	0.8												
															5	85.0	2U	3500	0.8												
26-31	C	E	N	P	1.9	A4	9.0	Y			15703			0	3	84.0	3U	3400	0.8												
															2	90.0	3U	3200	0.8												
															4	85.0	2U	3750	0.5												
															5	84.0	2U	3450	0.5												
41-20	C	C	N	P	1.9	A4	9.0	Y			18151	62	31.00	72	3	88.0	3U	2300	2.6	86.0	4L	1800	3.8								
															2	88.0	2U	2600	1.8												
															4	87.0	3U	2200	2.6												
															5	85.0	3U	2300	2.6												
46-06	C	E	N	P	1.9	A4	9.0	Y			13221		29.44	75	3	89.0	3U	2775	1.0	F				N			N				
															2	91.0	3U	2700	1.0												
															4	87.0	3U	2675	1.0												
															5	86.0	3U	2800	1.0												
05-08	C	F	N	P	1.9	M5	9.0	Y			14080	70		50	3					92.0	3	3760	2.0	N	92.9	83.3					
															2	93.0	3	3620	0.8												
															4	87.0	3	1080	0.4												
															5					85.0	3	3620	2.0								
28-15	C	F	N	P	1.9	A4	9.0	Y			15984	70	29.36	50	3	89.0	2U	2700	0.5	86.0	4L	1400	2.5								
															2	91.0	2U	2700	0.5												
															4	88.0	4L	1400	1.5												
															5	86.0	4L	1400	1.5												

1991 CRC OCTANE NUMBER REQUIREMENT SURVEY

OBS. NO.	VEHICLE DESCRIPTION: TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE: AS RCD	AS TST	ODOM MILES	WEATHER: AMB TMP	BAROM	HUM	OCTANE NUMBER REQUIREMENT DATA: FUEL	MAXIMUM: OCT NO	GEAR	RPM	VAC	PART-THROTTLE: OCT NO	GEAR	RPM	VAC	TANK FUEL INFORMATION: OWKNK	OCT NO: RES	MOTR	RATER: KNINT	THR	GEAR	RPM	VAC
23-10	C	F	Y	P	1.9	M5	9.5	Y			19210	25	28.97	18	3	84.0	4	2300	0.2	82.0	4	1800	1.0								
															2	84.0	4	2300	0.2												
															4	84.0	4	2200	0.2												
															5	84.0	4	2300	0.2												
23-09	C	F	Y	T	1.9	M5	9.3	N			6019	41	29.02	23	3	82.0	4	1200	0.2	82.0	4	1200	1.0								
															2	82.0	4	1300	0.2	82.0	4	1300	1.0								
															4	82.0	4	1200	0.2												
															5	L				L											
08-12	C	F	N	T	2.0	A3	8.8	Y	+ 8	+ 8	15741	81	29.75	67	3	94.0	2U	3325	0.9	92.0	3U	2550	4.0								
															2	94.0	3L	2050	1.0	92.0	3U	2600	4.0								
															4	92.0	3L	2075	1.0												
															5	94.0	3L	2050	1.0												
08-22	C	F	N	T	2.0	A3	8.8	Y	+ 8	+ 8	15931	72	29.98	50	3	94.0	3L	2300	1.0	92.0	3U	2450	5.5								
															2	96.0	2U	3000	0.8	94.0	3U	2450	5.5								
															4	92.0	3L	2300	1.0												
															5	94.0	3L	2200	1.0												
23-13	C	F	N	T	2.0	A3	8.8	Y	+ 8	+ 8	10466	53	29.37	21	3	89.0	3L	2200	1.0	85.0	3L	2200	2.0								
															2	88.0	3L	2200	1.0												
															4	88.0	3L	2200	1.0												
															5	89.0	3L	2200	1.0												
05-22	C	F	N	T	2.0	A3	8.8	Y	+ 8	+ 8	14873	70	29.80	20	3	96.0	3L	2400	0.8	95.0	3L	2800	4.0								
															2	97.0	3L	2350	0.8	97.0	3L	2850	4.0								
															4	95.0	3L	2350	0.8												
															5	95.0	3L	2350	0.8	95.0	3L	2750	4.0								
29-30	C	F	N	P	2.0	M5	9.0	Y	+ 5	+ 5	14939	71	29.49	61	3	89.5	5	2000	0.4	89.5	5	2000	2.0								
															2	90.5	3	2000	0.4												
															4	91.5	5	1600	0.4												
															5																
05-13	C	F	N	P	2.0	A4	9.0	Y	+ 5	+ 5	9550	70	30.45	50	3	92.0	4	2500	0.4	F				N	92.0	82.5	A	M	4	2400	0.4
															2	94.0	4	2600	0.4												
															4	89.0	4	2500	0.4												
															5	90.0	4	2720	0.4												
28-16	C	F	Y	P	2.0	A4	9.5	Y	+15	+15	16280	70	29.10	50	3	L				L											
															2	L				L											
															4	76.0	4U	2100	1.0												
															5	L				L											
41-10	C	F	N	P	2.0	A4	8.5	Y	+ 5	+ 5	16528	62	30.22	65	3	87.0	4L	2250	0.3	87.0	4L	2250	1.3								
															2	87.0	4L	2300	0.3	87.0	4L	2300	1.3								
															4	86.0	4L	2250	0.3												
															5	87.0	4L	2300	0.3												
08-29	C	F	N	P	2.0	M5	9.3	Y	+10	+10	8303	69	29.90	38	3	86.0	3	2700	0.5	88.0	3	1600	2.0	N	95.2	84.6	N				
															2	88.0	3	3000	0.5	89.0	3	3000	2.0								
															4	86.0	3	2900	0.5	86.0	3	1600	2.0								
															5	L				86.0	3	1700	2.0								

1991 CRC OCTANE NUMBER REQUIREMENT SURVEY

	VEHICLE DESCRIPTION											WEATHER			OCTANE NUMBER REQUIREMENT DATA									TANK FUEL INFORMATION							
																MAXIMUM				PART-THROTTLE							RATER				
OBS. NO.	TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE AS RCD	SPARK ADVANCE AS TST	ODOM MILES	AMB TMP	BAROM	HUM	FUEL	OCT NO	GEAR	RPM	VAC	OCT NO	GEAR	RPM	VAC	OWKNK	OCT NO RES	OCT NO MOTR	KNINT	THR	GEAR	RPM	VAC
07-10	C	F	N	P	2.0	M5	9.3	Y	+10	+10	27675	72	30.12	72	3	88.0	3	3000						N			N				
															2	89.0	3	3700													
															4	87.0	3	2800													
															5	87.0	3	3450													
08-04	C	F	N	P	2.0	A4	9.3	Y	+10	+10	22145	77	29.86	88	3	82.0	2U	2600	0.6	80.0	3U	2300	2.0								
															2	82.0	3L	2550	0.7												
															4	80.0	3U	2600	0.7												
															5	L				L											
28-21	C	F	N	P	2.0	A4	9.3	Y	+10	+10	17004	70	29.58	50	3	83.0	4L	1700	0.5	82.0	4L	1600	1.5								
															2	84.0	4L	1700	0.5												
															4	82.0	4L	1700	0.5												
															5	L				L											
28-24	C	F	N	P	2.0	A4	9.3	Y	+10	+10	7426	70	29.45	50	3	87.0	4L	1600	0.5	86.0	4L	1600	1.5								
															2	87.0	4L	1600	0.5												
															4	85.0	4L	1600	0.5												
															5	86.0	4L	1600	0.5												
29-29	C	F	N	P	2.0	A4	9.3	Y	+10	+10	13195	72	29.59	60	3	91.0	2U	3950	0.8	88.0	4L	1800	2.0								
															2	93.5	2U	4100	0.8												
															4	90.0	2U	2900	0.8												
															5	90.0	2U	2900	0.8												
46-03	C	E	N	P	2.0	A4	9.3	Y	+10	+10	19234	72	29.22	44	3					83.0	4U	1600	2.0								
															2	84.0	4U	1665	1.0												
															4					81.0	4U	1690	2.0								
															5	84.0	3U	2225	1.0												
47-09	C	C	N	P	2.0	A4	9.3	Y			19500	70	29.93	50	3	88.5	4L	1700	0.6	89.0	4L	1700	1.5								
															2	89.0	4L	1750	0.6												
															4	88.0	2U	3000	0.5												
															5	87.0	4L	1700	0.6												
28-22	C	F	Y	P	2.0	A4	10.8	Y			15128	70	29.20	50	3	L				L											
															2	L				L											
															4	77.0	4U	2550	0.8												
															5	L				L											
07-09	C	F	N	P	2.2	A4	8.6	Y	+ 6	+ 6	13448	70	30.40	0	3	91.0	4U	2400	0.0												
															2	93.0	4L	1900	0.0												
															4	86.0	3U	2800	0.0												
															5	87.0	3U	3000	0.0												
32-06	C	F	Y	TP	2.2	M5	7.8	Y			11341	70	29.58	50	3	83.0	3	4500	-7.0	83.0	3	4750	-6.0	N	92.4	83.3					
															2	84.0	3	4200	-7.0	84.0	3	4500	-6.0								
															4	82.0	3	4500	-7.0	82.0	3	4600	-6.0								
															5	L				L											
23-21	C	F	N	T	2.2	M5	9.0	Y			6613	20	29.28	18	3	85.0	4	2250	0.5	86.0	4	2250	2.5								
															2	86.0	4	2250	0.5	86.0	4	2250	2.5								
															4	84.0	4	1500	0.5	85.0	4	1500	2.0								
															5	L				L											

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OBS. NO.	TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE AS RCD	SPARK ADVANCE AS TST	ODOM MILES	AMB TMP	BAROM	HUM	FUEL	MAXIMUM OCT NO	MAXIMUM GEAR	MAXIMUM RPM	MAXIMUM VAC	PART-THROTTLE OCT NO	PART-THROTTLE GEAR	PART-THROTTLE RPM	PART-THROTTLE VAC	OWNK	TANK OCT NO RES	TANK OCT NO MOTR	RATER KNINT	RATER THR	RATER GEAR	RATER RPM	RATER VAC
08-01	C	F	N	T	2.2	A3	9.0	Y			9636	72	30.01	58	3	90.0	3L	1550	2.0	88.0	3L	1550	6.0								
															2	90.0	3L	1600	2.0	90.0	3U	2050	9.0								
															4	89.0	3L	1700	2.0												
															5	90.0	3L	1600	2.0												
08-25	C	F	N	T	2.2	A3	9.0	Y			8020	74	29.74	83	3	93.0	3L	1900	2.0	93.0	3L	1650	4.5	N	95.2	84.6	N				
															2	93.0	3L	1650	2.0	95.0	3L	1650	4.5								
															4	89.0	3L	1700	2.0												
															5	92.0	3L	1850	2.0	92.0	3L	1600	4.5								
47-10	C	C	N	T	2.2	A3	9.0	Y			20540	70	30.04	50	3	94.0	2U	3500	1.0	101.0	3L	1600	8.0								
															2	96.0	2U	4000	1.0	102.0	3L	1900	8.0								
															4	90.0	3L	2000	1.0												
															5	93.0	2U	4500	1.0	100.0	3L	1600	8.0								
05-19	C	F	N	T	2.2	A3	9.0	Y			6275	70	30.00	41	3	92.0	3L	1700	2.0	F				N	93.8	81.6	8	M	3U	2750	1.0
															2	93.0	3U	2800	1.0												
															4	91.0	3L	1950	2.0												
															5	91.0	3L	1700	2.0												
05-24	C	F	N	T	2.2	A3	9.0	Y			15250	70	29.90	18	3	90.0	3L	2100	2.0	87.0	3L	2200	4.0								
															2	92.0	3L	2200	2.0												
															4	88.0	3L	2150	2.0												
															5	89.0	3L	2000	2.0												
05-15	C	F	N	P	2.2	M5	8.8	Y	+15	+15	10795	70	30.10	31	3	89.0	3	3900	0.5	F				N	92.9	81.3	N				
															2	91.0	3	3750	0.5												
															4	89.0	3	2300	0.5												
															5	88.0	3	2700	0.5												
05-21	C	F	N	P	2.2	M5	8.8	Y	+15	+15	18960	70	30.30	20	3	92.0	4	3200	0.5	F				N	94.4	83.6	N				
															2	93.0	3	3750	0.5												
															4	89.0	4	2550	0.5												
															5	89.0	3	3900	0.5												
28-11	C	F	N	P	2.2	A4	8.8	Y	+15	+15	15628	70	29.40	50	3	89.0	2U	5100	0.5	84.0	3U	2400	1.5								
															2	91.0	2U	5100	0.5												
															4	87.0	2U	5100	0.5												
															5	88.0	2U	5100	0.5												
29-11	C	F	N	P	2.2	A4	8.8	Y	+15	+15	16025	74	29.50	63	3	93.5	2U	4800	0.6	94.0	3L	3700	1.6								
															2	97.5	2U	4800	0.6												
															4	87.5	4L	2500	0.6												
															5	95.0	2U	5000	0.6												
29-16	C	F	N	P	2.2	A4	8.8	Y	+15	+15	14800	74	29.30	82	3	88.0	4L	2700	0.6	87.5	4L	2400	1.6								
															2	94.5	2U	5000	0.6												
															4	85.0	4L	3000	0.6												
															5	85.0	4L	2400	0.6												
40-09	C	F	N	P	2.2	A4	8.8	Y	+15	+15	10229	32	29.24	10	3	90.5	2U	4300	0.0	86.0	3U	3000	2.0								
															2	93.5	2U	4600	0.0												
															4																
															5																

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OBS. NO.	VEHICLE DESCRIPTION TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE AS RCD	AS TST	ODOM MILES	WEATHER AMB TMP	BAROM	HUM	FUEL	OCTANE NUMBER REQUIREMENT DATA MAXIMUM OCT NO	GEAR	RPM	VAC	PART-THROTTLE OCT NO	GEAR	RPM	VAC	TANK FUEL INFORMATION OWKNK	OCT NO RES	OCT NO MOTR	KNINT	THR	RATER GEAR	RPM	VAC
40-10	C	F	N	P	2.2	A4	8.8	Y	+15	+15	10285	32	29.94	10	3	90.0	2U	4200	0.0	86.0	3U	3000	2.5								
															2	94.0	2U	4500	0.0												
															4	87.0	2U	4000	0.0												
															5																
47-16	C	C	N	P	2.2	A4	8.8	Y	+15	+15	12400	70	30.10	50	3	95.0	4U	3000	0.5	93.5	4U	3000	1.5	N	93.0	82.0	A	M	4U	2800	0.
															2	96.0	4U	3000	0.5												
															4	90.0	4U	2600	0.5												
															5	92.0	4U	2600	0.5												
41-21	C	C	N	P	2.2	A4	8.8	Y	+13	+15	8062	67	29.93	68	3	90.0	3U	2600	0.8	F											
															2	92.0	2U	4000	0.6												
															4	86.0	3U	3600	0.8												
															5	86.0	3U	3900	0.8												
41-01	C	C	N	P	2.2	M5	9.5	Y			6152	70	30.22	55	3	94.0	4	3000	0.4	92.0	4	3000	1.5								
															2	95.0	4	3000	0.4												
															4	93.0	4	3000	0.4												
															5	94.0	4	3000	0.4												
32-16	C	F	N	P	2.3	A4	9.2	Y	+10	+10	14059	70	29.61	50	3	89.0	4L	2200	1.0	89.0	4L	1950	2.0	N			N				
															2	90.0	4L	2250	1.0	90.0	4L	2000	2.0								
															4	88.0	4L	2300	1.0	88.0	4L	2000	2.0								
															5	88.0	4L	2200	1.0	88.0	4L	1950	2.0								
28-09	C	F	N	P	2.3	A4	9.2	Y	+10	+10	16524	70	29.03	50	3	91.0	2U	2700	0.5	89.0	4L	1700	3.0								
															2	93.0	2U	4100	1.0												
															4	89.0	2U	2700	0.5												
															5	88.0	2U	2700	0.5												
40-05	C	F	N	P	2.3	A3	9.0	Y	+15	+15	10199	46	29.97	40	3	92.5	2	3500	0.0	89.0	3	3000	2.5								
															2	92.0	3	3200	0.0												
															4	91.0	3	3200	0.0												
															5																
40-06	C	F	N	P	2.3	A3	9.0	Y	+15	+15	10232	46	29.97	40	3	92.0	2	3200	0.0	F											
															2	92.5	2	3200	0.0												
															4	89.0	2	3300	0.0												
															5	91.0	2	3500	0.0												
46-02	C	E	N	P	2.3	A3	9.0	Y	+15	+15	10870	70	28.70	0	3	91.0	3	2950	1.0	F				N	90.6	83.3	N				
															2	92.0	3	2845	1.0												
															4	87.0	3	2650	1.0												
															5	88.0	3	2825	1.0												
05-03	C	F	N	P	2.3	A3	9.0	Y			16500	70	29.82	50	3	88.0	3	2750	0.4	F											
															2	91.0	2	4200	0.8												
															4	86.0	3	2800	0.3												
															5	86.0	3	2670	0.4												
41-22	C	C	N	P	2.3	A3	9.0	Y	+15	+15	18521	79	30.04	45	3	86.0	3	2400	1.4	85.0	3	2100	3.0								
															2	88.0	3	2350	1.4												
															4	86.0	3	2450	1.4												
															5	85.0	2	2800	1.0												

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VEHICLE DESCRIPTION												WEATHER			OCTANE NUMBER REQUIREMENT DATA									TANK FUEL INFORMATION							
																MAXIMUM				PART-THROTTLE							RATER				
OBS. NO.	TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE AS RCD	AS TST	ODOM MILES	AMB TMP	BAROM	HUM	FUEL	OCT NO	GEAR	RPM	VAC	OCT NO	GEAR	RPM	VAC	OWKNK	OCT NO RES	MCTR	KNINT	THR	GEAR	RPM	VAC
32-05	C	F	N	P	2.3	A3	9.0	Y	+10	+10	10124	70	29.71	50	3	91.0	2	4600	1.0	89.0	3	3600	2.0								
															2	92.0	2	4500	1.0	90.0	3	3600	2.0								
															4	91.0	2	4600	1.0	89.0	3	3600	2.0								
															5	90.0	2	4650	1.0	88.0	3	3550	2.0								
40-11	C	F	Y	P	2.3	A3	9.5	Y			10746	46	29.97	21	3	89.0	3L	1800	1.0	89.0	3L	2200	2.0								
															2	89.0	3L	1800	1.0												
															4																
															5	87.0	3L	1800	1.0												
40-12	C	F	Y	P	2.3	A3	9.5	Y			10890	46	29.97	21	3	88.0	2U	4300	0.0	86.0	3L	1800	6.0								
															2	90.0	2U	4300	0.0												
															4																
															5	86.0	3L	1800	0.0												
28-17	C	F	Y	P	2.3	M5	10.0	Y			16152	70	29.20	50	3	86.0	3	1700	0.5	84.0	4	1300	1.5								
															2	86.0	4	2100	0.5												
															4	84.0	4	2300	0.5												
															5	84.0	4	1900	0.5	L											
08-19	C	F	Y	P	2.3	A3	9.5	Y			6168	78	29.82	57	3	L				80.0	3U	1775	11.0								
															2	L				86.0	3U	1800	11.0								
															4	78.0	2U	2800	0.5	76.0	3U	1850	10.0								
															5	L				L											
05-27	C	F	N	P	2.3	A4	9.8	Y			11108	70	29.70	33	3	95.0	3	2850	0.5	93.0	3	2000	3.5								
															2	96.0	2	3100	0.5												
															4	94.0	3	2800	0.5												
															5	94.0	3	2600	0.5												
05-10	C	F	N	P	2.4	A4	9.0	Y	+ 5	+ 5	10634	70	30.55	50	3					101.0	4	2350	6.0	Y	92.4	82.5	A	P	4		
															2	97.0	4	2580	1.0	98.0	4	2170	4.0								
															4	93.0	4	2640	1.0												
															5					99.0	4	2200	6.0								
62-01	C	F	N	P	2.4	A4	8.6	Y	+12	+15	16375	82	29.20	34	3	95.0	3L	2300	1.7	92.0	3L	2400	2.0								
															2	96.0	3L	2400	1.5												
															4																
															5	94.0	3U	2200	1.2												
26-03	C	E	N	P	2.4	A4	8.6	Y	+15	+15	18256	88	29.80	0	3	95.0	4U	2350	0.3	95.0	4U	2100	4.4								
															2	96.0	4U	2050	0.3	96.0	4U	2000	4.4								
															4	96.0	4U	2100	0.3	96.0	4U	2100	4.4								
															5	96.0	4U	2200	0.3	96.0	4U	2250	4.4								
08-20	C	F	N	T	2.5	A3	8.9	Y	+12	+12	26090	72	30.00	50	3	91.0	2U	2200	0.8	92.0	3U	1900	5.0								
															2	91.0	3U	2100	1.8	92.0	3U	1900	5.0								
															4	90.0	2U	2150	0.8	90.0	3U	1950	5.0								
															5	93.0	3U	2100	1.8												
08-24	C	A	N	T	2.5	A3	8.9	Y	+12	+12	23618	72	29.52	54	3	86.0	3L	2000	1.6	84.0	3U	1850	3.0								
															2	87.0	3U	2150	1.5												
															4	85.0	2U	2100	0.7	82.0	3U	2100	3.0								
															5	84.0	3L	2050	1.6												

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	VEHICLE DESCRIPTION												WEATHER			OCTANE NUMBER REQUIREMENT DATA									TANK FUEL INFORMATION							
																	MAXIMUM				PART-THROTTLE							RATER				
OBS. NO.	TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE AS RCD	SPARK ADVANCE AS TST	ODOM MILES	AMB TMP	BAROM	HUM	FUEL	OCT NO	GEAR	RPM	VAC	OCT NO	GEAR	RPM	VAC	OWKNK	OCT NO RES	OCT NO MOTR	KNINT	THR	GEAR	RPM	VAC
28-19	C	F	N	T	2.5	A3	8.9	Y	+12	+12	17003	70	29.49	50	3	86.0	3L	1700	1.5	85.0	3L	1700	2.5								
															2	87.0	3L	1700	1.5												
															4	86.0	3L	1600	1.5												
															5	85.0	3L	1700	1.5												
29-04	C	F	N	T	2.5	A3	8.9	Y	+12	+12	20339	74	29.62	56	3	89.0	3L	2700	1.0	88.0	3L	2500	2.0								
															2	92.0	3U	2800	1.0												
															4	88.0	3L	2300	1.0												
															5	87.5	2U	2100	1.0												
29-28	C	F	N	T	2.5	A3	8.9	Y	+12	+12	14669	72	29.75	60	3	88.0	3U	3000	1.0	87.0	3L	2000	2.0								
															2	91.0	2U	2400	1.0												
															4	89.0	3L	2000	1.0												
															5	88.0	3U	2000	1.0												
41-14	C	C	N	T	2.5	A3	8.9	Y	+10	+12	16994	57	30.45	58	3	91.0	3U	2450	2.0	88.0	3U	2100	3.4								
															2	93.0	3U	2200	2.0												
															4	88.0	3U	2300	2.0												
															5	91.0	3U	2250	2.0												
28-20	C	F	Y	TP	2.5	A3	7.8	Y	+12	+12	15657	70	29.36	50	3	91.0	2U	2800	4.0	88.0	3L	2000	2.0								
															2	91.0	2U	2800	4.0												
															4	91.0	2U	2800	4.0												
															5	91.0	2U	2700	4.0												
05-28	C	F	N	T	2.5	A3	8.9	Y	+12	+12	9379	70	30.10	30	3	87.0	2U	2200	0.8	F											
															2	88.0	2U	2250	0.8												
															4	86.0	2U	2200	0.8												
															5	86.0	2U	2150	0.8												
47-06	C	C	N	T	2.5	A3	8.3	Y			9392	70	30.23	50	3					99.0	3L	1900	10.0								
															2					102.0	3L	1900	10.0								
															4	86.0	3U	2750	0.8	84.0	3L	1900	10.0								
															5					99.0	3L	1900	10.0								
28-26	C	F	N	T	2.5	A3	8.3	Y			14921	70	29.12	50	3	93.0	3U	1925	2.5	93.0	3U	2000	8.0								
															2	97.0	3U	1925	2.5	97.0	3U	2000	9.0								
															4	84.0	2U	2600	1.5												
															5	90.0	3U	1925	2.5	90.0	3U	2000	9.0								
05-20	C	F	N	T	2.5	A3	8.3	Y			13303	70	30.00	37	3					95.0	3U	2250	5.0	N	92.2	81.1	A	N	3L	2000	3.0
															2	95.0	3L	2050	3.0	97.0	3U	2250	5.0								
															4					94.0	3U	2250	5.0								
															5					94.0	3U	2200	5.0								
41-06	C	C	N	T	2.5	A3	8.3	Y			15516	62	30.30	52	3	103.0	3U	2700	1.4	103.0	3U	2500	3.0								
															2	103.0	3U	2800	1.4	103.0	3U	2550	3.4								
															4	100.0	3U	2500	1.4	100.0	3U	2600	2.8								
															5	105.0	3U	2650	1.4	105.0	3U	2600	3.2								
23-26	C	F	N	T	2.5	A3	8.3	Y			14594	40	29.20	22	3	91.0	3U	3300	0.5	F											
															2	92.0	3U	3300	0.5												
															4	86.0	3U	3300	0.5												
															5	88.0	3U	3300	0.5												

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OBS. NO.	VEHICLE DESCRIPTION: TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE: AS RCD	AS TST	ODOM MILES	WEATHER: AMB TMP	BAROM	HUM	OCTANE NUMBER REQUIREMENT DATA: FUEL	MAXIMUM: OCT NO	GEAR	RPM	VAC	PART-THROTTLE: OCT NO	GEAR	RPM	VAC	TANK FUEL INFORMATION: OWKNK	OCT NO: RES	MOTR	RATER: KNIT	THR	GEAR	RPM	VAC
05-02	C	F	Y	P	2.5	A4	9.0	Y	+10	+10	15757	70	30.22	50	3	91.0	2U	3300	0.5	F											
															2	93.0	2U	3300	0.5												
															4	88.0	3U	2500	1.0												
															5	86.0	3U	2960	1.0												
41-02	C	C	Y	P	2.5	A4	9.0	Y			8679	70	30.24	54	3	94.0	4L	2500	0.6	F				N	93.0	83.0	N				
															2	95.0	4L	2500	0.6												
															4	91.0	4L	2500	0.6												
															5	95.0	4L	2500	0.6												
07-08	C	F	N	P	3.0	A4	8.9	Y			4324	68	30.48	25	3	87.0	4L	1950						N			N				
															2	87.0	4L	2000													
															4	86.0	4L	2000													
															5	87.0	4L	2050													
40-07	C	F	N	P	3.0	A4	8.9	Y	+12	+12	10339	45	29.93	35	3	86.0	4L		0.0	84.0	4L		2.5								
															2	88.0	3U		0.0												
															4	86.0	4L		0.0												
															5																
40-08	C	F	N	P	3.0	A4	8.9	Y	+12	+12	10345	45	29.90	35	3	86.0	3U		0.0	84.0	3U		3.0								
															2	88.0	3U		0.0												
															4	85.0	3U		0.0												
															5	84.0	3U		0.0												
05-23	C	F	N	P	3.0	A4	9.3	Y			17186	70	30.10	27	3	90.0	4U	1350	0.5	89.0	4U	1250	5.0								
															2	91.0	4U	1350	0.5												
															4	89.0	4U	1300	0.5												
															5	89.0	4U	1500	0.5												
28-10	C	F	N	P	3.0	A4	9.3	Y	+10	+10	15534	70	29.20	50	3	88.0	4U	1000	0.8	86.0	4U	1000	1.8								
															2	88.0	4L	1200	0.8												
															4	88.0	4U	1000	0.8												
															5	88.0	4U	1000	0.8												
28-27	C	F	N	P	3.0	A4	9.3	Y			10547	70	29.20	50	3	89.0	3U	2300	0.5	87.0	4L	1400	3.0								
															2	90.0	3U	2700	0.5												
															4	89.0	2U	1400	0.5												
															5	89.0	3U	2300	0.5												
07-11	C	F	N	P	3.0	A4	9.3	Y	+10	+10	9791	72	29.74	0	3	88.0	4U	2900						N			N				
															2	89.0	3U	3000													
															4	85.0	4U	2600													
															5	84.0	4L	1700													
06-01	C	F	N	P	3.0	A4	9.3	Y			21763	30	29.80	17	3	91.0	4U	1700	0.5	89.0	4U	1700	2.0								
															2	92.0	4U	1900	0.5	91.0	4U	1900	1.8								
															4	91.0	4U	1900	0.5	90.0	4U	1600	1.8								
															5	91.0	4U	1800	0.5	89.0	4U	1700	2.0								
05-14	C	F	N	P	3.0	A4	9.3	Y	+10	+10	9758	68	29.80	22	3	92.0	3U	2500	0.5	F				N	91.9	81.5	A	M	3U	2850	0.5
															2	94.0	3U	2550	0.5												
															4	90.0	3U	2600	0.5												
															5	90.0	3U	2500	0.5												

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OBS. NO.	TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE AS RCD	SPARK ADVANCE AS TST	ODOM MILES	AMB TMP	BAROM	HUM	FUEL	MAXIMUM OCT NO	MAXIMUM GEAR	MAXIMUM RPM	MAXIMUM VAC	PART-THROTTLE OCT NO	PART-THROTTLE GEAR	PART-THROTTLE RPM	PART-THROTTLE VAC	OWKNK	TANK FUEL OCT NO RES	TANK FUEL OCT NO MOTR	RATER KNIT	RATER THR	RATER GEAR	RATER RPM	RATER VAC
41-12	C	C	N	P	3.0	A4	9.3	Y	+10	+10	17156	60	30.32	64	3	92.0	3L	2300	2.4	F											
															2	95.0	3U	2100	1.6												
															4	90.0	3U	3150	1.6												
															5	92.0	3L	2750	2.4												
32-09	C	F	Y	P	3.0	M5	9.8	Y	+10	+10	22688	70	29.57	50	3	86.0	4	1900	0.3	86.0	4	1900	3.0	N			N				
															2	87.0	4	2000	0.3	87.0	4	1800	3.0								
															4	86.0	4	1900	0.3	86.0	4	1900	3.0								
															5	85.0	4	1900	0.3	85.0	4	1800	3.0								
29-02	C	F	N	P	3.0	A4	9.3	Y	+10	+10	16747	70		58	3	94.5	3U	2700	0.8	91.0	4L	1700	2.0								
															2	96.0	3U	2500	0.8												
															4	92.0	3U	2600	0.8												
															5	94.0	3U	3000	0.8												
28-14	C	F	Y	P	3.0	A4	8.5	Y	+ 8	+ 8	18424	70	29.81	50	3	86.0	4L	1400	0.8	86.0	4L		1.8								
															2	86.0	4L	1500	0.8												
															4	85.0	4L	1400	0.8												
															5	85.0	4L	1400	0.8												
28-25	C	F	Y	P	3.0	A4	9.0	Y	+15	+15	21110	70	29.36	50	3	86.0	2U	2100	0.5	84.0	3U	2100	2.8								
															2	87.0	2U	2400	0.5												
															4	85.0	2U	2500	0.5												
															5	85.0	2U	2100	0.5												
47-22	C	C	Y	P	3.0	A4	9.0	Y	+15	+15	21121	70	30.08	50	3	89.0	3U	2600	0.7	87.0	4U	2000	3.0								
															2	91.0	3U	2600	0.7												
															4	88.0	3U	2600	0.7												
															5	89.0	2U	2600	0.5												
62-03	C	F	Y	P	3.0	A4	9.0	Y	+15	+15	6516	76	29.12	53	3	86.0	3U	2500	0.5	84.0	3U	2300	1.0								
															2	86.0	3U	2200	0.7	85.0	3U	2300	1.0								
															4	87.0	3U	2300	0.6												
															5	87.0	3U	2200	0.7												
60-05	C	F	Y	P	3.0	A4	9.2	Y	+10	+10	10637	77	29.51	25	3	84.0	3L	2500	0.7	83.0	4U	2000	1.4								
															2	82.0	4U	1900	0.9												
															4	84.0	4U	2100	0.8												
															5	L				L											
40-13	C	F	Y	P	3.1	A3	8.8	Y			10520	46	29.97	21	3	96.0	3L	2700	1.0	F											
															2	98.0	3L	2500	1.0												
															4																
															5																
08-02	C	F	Y	P	3.1	A3	8.8	Y			16704	72	29.40	58	3	82.0	3U	3200	2.0	L											
															2	84.0	3U	2700	2.0												
															4	81.0	3U	2900	2.0												
															5	L				L											
08-21	C	F	Y	P	3.1	A3	8.8	Y			7099	70	30.08	49	3	82.0	2U	2800	0.8	80.0	3U	2250	5.0								
															2	85.0	2U	2900	0.8												
															4	80.0	2U	2750	0.8												
															5	L				L											

1991 CRC OCTANE NUMBER REQUIREMENT SURVEY

	VEHICLE DESCRIPTION											WEATHER			OCTANE NUMBER REQUIREMENT DATA									TANK FUEL INFORMATION							
																MAXIMUM				PART-THROTTLE							RATER				
OBS. NO.	TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE AS RCD	SPARK ADVANCE AS TST	ODOM MILES	AMB TMP	BAROM	HUM	FUEL	OCT NO	GEAR	RPM	VAC	OCT NO	GEAR	RPM	VAC	OWKNK	OCT NO RES	OCT NO MOTR	KNINT	THR	GEAR	RPM	VAC
47-23	C	C	Y	P	3.1	A3	8.8	Y			14130	70	30.06	50	3	94.0	3L	2250	2.3	95.0	3L	2100	3.5								
															2	94.0	3L	2250	2.3												
															4	85.0	3L	2100	2.3												
															5	86.0	3L	2400	2.3												
41-23	C	C	Y	P	3.1	A3	8.8	Y			8301	69	29.95	62	3	85.0	2U	3100	1.0	83.0	3L	2050	5.2								
															2	84.0	2U	1500	1.0												
															4	84.0	2U	1500	1.0												
															5	L															
08-11	C	F	Y	P	3.1	A3	8.8	Y			11571		29.69	0	3	L				L											
															2	80.0	3L	1900	2.5												
															4	L				L											
															5	L				L											
08-27	C	F	Y	P	3.1	A3	8.8	Y			18109	74	30.09	46	3	80.0	3L	1900	2.5	80.0	3U	2200	7.0								
															2	82.0	3L	2000	2.5	85.0	3U	2200	7.0								
															4	78.0	3L	1750	2.5												
															5	L				L											
28-28	C	F	Y	P	3.1	A3	8.8	Y			7948	70	29.21	50	3	80.0	3L	1900	2.0	L											
															2	85.0	2U	2800	0.5												
															4	79.0	3L	1900	2.0												
															5	L				L											
07-03	C	F	Y	P	3.1	A4	8.8	Y			7332	72	29.95	0	3	80.0	4U	2900		L				N			N				
															2	80.0	4U	3100													
															4	80.0	4U	2800													
															5	L				L											
40-02	C	F	Y	P	3.1	A4	8.8	Y			14650	91	29.94	115	3	89.0	2L	2500	1.0	87.0	4L	2000	3.0								
															2	91.0	3L	2000	1.0												
															4	86.0	4L	1600	1.0												
															5	87.0	4L	1600	1.0												
46-04	C	E	Y	P	3.1	A4	8.8	Y			8107	61	29.26	36	3	81.0	4L	1925	1.0	L											
															2	81.0	4L	1900	1.0												
															4	79.0	3U	2700	1.0												
															5	84.0	2U	2900	1.0												
23-12	C	F	Y	P	3.1	A4	8.8	Y			9480	56	28.85	46	3	82.0	4L	1700	0.5	82.0	3U	3100	2.0								
															2	84.0	3U	3100	1.0												
															4	84.0	3L	1800	1.0												
															5	84.0	4L	1700	0.5												
23-05	C	F	Y	P	3.1	A4	8.5	Y	+10	+10	6737	57	29.09	30	3	82.0	4L	1500	0.8	82.0	4L	1500	2.0								
															2	82.0	4L	1500	0.8	82.0	4L	1500	2.0								
															4	83.0	4L	1500	0.8	83.0	4L	1500	2.0								
															5	84.0	4L	1500	0.8	84.0	4L	1500	2.0								
08-09	C	F	Y	P	3.1	A4	8.8	Y			10816	68	29.85	44	3	85.0	4L	1425	0.8	85.0	3U	2150	7.0								
															2	86.0	4L	1500	1.0	86.0	3U	2275	7.0								
															4	82.0	3L	1950	1.5												
															5	86.0	4L	1450	0.8												

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OBS. NO.	TYPE (VEHICLE DESCRIPTION)	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE AS RCD	SPARK ADVANCE AS TST	ODOM MILES	AMB TMP (WEATHER)	BAROM	HUM	FUEL	MAXIMUM OCT NO	MAXIMUM GEAR	MAXIMUM RPM	MAXIMUM VAC	PART-THROTTLE OCT NO	PART-THROTTLE GEAR	PART-THROTTLE RPM	PART-THROTTLE VAC	OWKNK (TANK FUEL INFORMATION)	OCT NO RES	OCT NO MOTR	KNINT	THR	RATER GEAR	RPM	VAC
47-08	C	C	Y	P	3.1	A4	8.8	Y			9330	70	30.15	50	3	88.0	4L	1700	0.8	87.0	4L	1700	2.0								
															2	88.0	4L	1700	0.8												
															4	88.0	4L	1500	0.8												
															5	88.0	4L	1600	0.8												
47-01	C	C	Y	P	3.1	A4	8.8	Y			9500	70	29.98	50	3	87.0	4L	1500	1.0	87.0	4L	1500	2.5								
															2	87.0	4L	1800	1.0												
															4	87.0	4L	1600	1.0												
															5	87.0	4L	1600	1.0												
47-02	C	C	Y	P	3.1	A4	8.8	Y			8150	70	29.96	50	3	88.0	4L	1650	1.2	88.0	4L	1650	3.0								
															2	88.0	4L	2000	1.2												
															4	88.0	4L	1700	1.2												
															5	88.0	4L	1600	1.2												
47-03	C	C	Y	P	3.1	A4	8.8	Y			6100	70	29.98	58	3	91.0	4L	1750	1.0	92.0	4L	1600	3.0								
															2	91.0	4L	1750	1.0												
															4	89.0	4L	1600	1.0												
															5	87.0	4L	1650	1.0												
47-13	C	C	Y	P	3.1	A4	8.8	Y			22631	70	29.94	50	3	88.0	4L	1650	0.6	86.5	4L	1750	2.0								
															2	88.0	4L	1800	0.6												
															4	88.0	4L	1550	0.6												
															5	88.0	4L	1600	0.6												
28-12	C	F	Y	P	3.2	A4	9.6	Y			15537	70	29.00	50	3	92.0	4U	1800	0.8	89.0	4U	1800	1.8								
															2	92.0	4U	1800	0.8												
															4	92.0	4U	1700	0.8												
															5	91.0	4U	1800	0.8												
05-25	C	F	N	P	3.3	A4	8.9	Y			16670	70	29.80	40	3	89.0	2U	2700	1.0	F											
															2	91.0	3U	2800	2.0												
															4	88.0	3U	2700	2.0												
															5	88.0	3U	2650	2.0												
41-13	C	C	N	P	3.3	A4	8.9	Y			14662	63	30.37	61	3	96.0	3U	2250	1.8	F											
															2	97.0	3U	2200	1.8												
															4	95.0	4U	2050	2.8												
															5	96.0	4U	2200	2.8												
26-04	C	E	Y	P	3.3	A4	8.9	Y			17492	74	30.18	0	3	88.0	2U	4300	0.6												
															2	88.0	2U	4250	0.6												
															4	89.0	3U	3100	0.6	89.0	3U	3150	1.5								
															5	87.0	3U	3200	0.6	87.0	3U	3050	1.5								
05-12	C	F	N	P	3.3	A4	8.9	Y			27285	70	30.10	50	3	80.0	3U	3200	1.0	F											
															2	84.0	2U	3300	1.0												
															4	79.0	3U	3000	1.0												
															5	L															
41-04	C	C	N	P	3.3	A4	8.9	Y			10482	70	29.90	54	3	95.0	4L	1900	1.4	F											
															2	96.0	4L	1900	1.4												
															4	92.0	4L	1900	1.4												
															5	96.0	4L	1900	1.4												

1991 CRC OCTANE NUMBER REQUIREMENT SURVEY

OBS. NO.	VEHICLE DESCRIPTION TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE AS RCD	AS TST	ODOM MILES	WEATHER AMB TMP	BAROM	HUM	FUEL	MAXIMUM OCT NO	GEAR	RPM	VAC	PART-THROTTLE OCT NO	GEAR	RPM	VAC	TANK FUEL INFORMATION OWKNK	OCT NO RES	MOTR	RATER KNINT	THR	GEAR	RPM	VAC
08-14	C	F	Y	P	3.3	A3	9.0	Y			9361	82	30.12	61	3	82.0	3L	1600	1.5	82.0	3L	1500	6.0								
															2	82.0	3L	1625	1.5	84.0	3L	1500	6.0								
															4	82.0	3L	1800	1.5												
															5	84.0	3L	1450	1.5												
08-28	C	F	Y	P	3.3	A3	9.0	Y			7995	73	29.64	48	3	82.0	3L	1425	1.5	82.0	3L	1425	5.0								
															2	82.0	3L	1400	1.5	82.0	3L	1400	5.0								
															4	82.0	3L	1300	1.5	82.0	3L	1350	5.0								
															5	L				L											
23-19	C	F	Y	P	3.3	A4	9.0	Y			10954	58	29.07	42	3	82.0	3L	2100	1.0	F											
															2	82.0	4L	1600	1.0												
															4	82.0	3U	2400	0.8												
															5	L				L											
23-20	C	F	Y	P	3.3	A3	9.0	Y			8471	39	28.91	26	3	82.0	3U	2400	1.6	F											
															2	84.0	3U	2400	1.6												
															4	83.0	3U	2400	1.6												
															5	L				L											
08-06	C	F	Y	P	3.3	A3	9.0	Y			7361		30.01	0	3	80.0	3L	1550	1.4	82.0	3L	1450	6.0								
															2	82.0	3L	1800	1.4	82.0	3L	1550	6.0								
															4	80.0	3L	1500	1.4												
															5	L				L											
41-03	C	C	Y	P	3.3	A3	9.0	Y			11217	60	30.32	50	3	103.0	3U	2150	0.8	103.0	3U	2000	2.5								
															2	103.0	3U	2100	0.8	103.0	3U	2000	3.0								
															4	100.0	3U	2100	0.8	100.0	3U	2050	2.6								
															5	105.0	3U	2050	0.8	105.0	3U	2050	3.0								
28-18	C	F	Y	P	3.4	A4	9.3	Y			15585	70	29.24	50	3	L				L											
															2	82.0	2U	4000	0.5												
															4	79.0	2U	4000	0.5												
															5	L				L											
29-21	C	F	Y	P	3.4	A4	9.3	Y			16085	72	29.53	57	3	84.5	2U	2500	0.5	84.0	3U	2100	6.0								
															2	86.0	3U	2300	0.8												
															4	82.0	3U	2400	0.8												
															5	85.5	2U	2500	0.5												
29-23	C	F	Y	P	3.4	A4	9.3	Y			12430	72	29.47	63	3	88.0	2U	2300	0.6	87.0	3U	2200	4.0								
															2	88.0	2U	2000	0.6												
															4	85.0	2U	3800	0.6												
															5	86.0	4L	1500	0.6												
05-05	C	F	N	P	3.8	A4	9.0	Y	+10	+10	9435	69	30.55	50	3	86.0	3L	2800	1.0	F											
															2	87.0	4L	1390	2.0												
															4	85.0	3L	2150	1.0												
															5	84.0	3U	2700	1.0												
07-07	C	F	N	P	3.8	A4	9.0	Y	+10	+10	23310	71	30.64	69	3	95.0	2	3700						N			N				
															2	95.0	2	3700													
															4	93.0	2	3700													
															5	94.0	2	3900													

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OBS. NO.	TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE AS RCD	SPARK ADVANCE AS TST	ODOM MILES	AMB TMP	BAROM	HUM	FUEL	MAXIMUM OCT NO	MAXIMUM GEAR	MAXIMUM RPM	MAXIMUM VAC	PART-THROTTLE OCT NO	PART-THROTTLE GEAR	PART-THROTTLE RPM	PART-THROTTLE VAC	OWKNK	OCT NO RES	OCT NO MOTR	RATER KNINT	RATER THR	RATER GEAR	RATER RPM	RATER VAC
32-13	C	F	Y	SP	3.8	A4	8.2	Y	+10	+10	11533	70	29.09	50	3	92.0	2	4100	-11.0	91.0	3	2700	-7.0	N			N				
															2	93.0	2	4100	-11.0	92.0	3	2700	-7.0								
															4	92.0	2	4100	-11.0	91.0	3	2800	-7.0								
															5	91.0	2	4000	-11.0	90.0	3	2700	-7.0								
32-11	C	F	N	P	3.8	A4	9.0	Y	+10	+10	17185	70	29.33	50	3	85.0	2U	3000	1.0	85.0	4L	1450	3.0	N			N				
															2	86.0	2U	3000	1.0	86.0	4L	1450	3.0								
															4	85.0	2U	3000	1.0	85.0	4L	1450	3.0								
															5	84.0	2U	3000	1.0	84.0	4L	1450	3.0								
08-08	C	F	Y	P	3.8	A4	8.5	Y			17417	76	29.87	70	3	L				L											
															2	80.0	4L	1300	1.0												
															4	78.0	4L	1325	1.0												
															5	L				L											
08-18	C	F	Y	P	3.8	A4	8.5	Y			16620	77	30.00	59	3	82.0	2U	2250	0.6	L											
															2	84.0	2U	2250	0.6												
															4	78.0	2U	2300	0.6												
															5	L				L											
29-19	C	F	Y	P	3.8	A4	8.5	Y			19693	73	29.50	79	3	86.0	3U	2000	1.0	86.0	3U	1900	6.0								
															2	89.0	3U	1950	1.0	89.0	3U	1950	6.0								
															4	86.0	3L	1600	1.0												
															5	84.0	3U	2000	1.0												
23-28	C	F	Y	P	3.8	A4	8.5	Y			12001	65	29.30	60	3	84.0	3U	2700	0.5	82.0	4L	1400	2.0								
															2	85.0	3U	2500	0.5												
															4	84.0	4L	1500	0.5												
															5	84.0	4L	1450	1.0												
29-01	C	F	Y	P	3.8	A4	8.5	Y			6031	70		58	3	88.0	4L	1400	1.0	87.0	4L	1300	2.0								
															2	90.0	3L	2300	1.0												
															4	86.0	4L	1300	1.0												
															5	87.0	4L	1300	1.0												
26-02	C	E	Y	P	3.8	A4	8.5	Y			24411		29.90	0	3	L				L											
															2	L				L											
															4	L				L											
															5	L				L											
28-04	C	F	Y	P	3.8	A4	8.5	Y			15747	70	29.42	50	3	86.0	4L	1200	0.5	85.0	4L	1300	2.0								
															2	87.0	4L	1200	0.5												
															4	84.0	4L	1300	0.5												
															5	84.0	4L	1200	0.5	L											
23-15	C	F	Y	P	3.8	A4	8.5	Y			13253	41	29.20	23	3	86.0	3U	3000	1.0	86.0	3U	3000	2.0								
															2	87.0	3U	2700	1.0	87.0	3U	3000	2.0								
															4	84.0	3U	3200	1.0												
															5	84.0	3U	3000	1.0												
41-07	C	C	Y	P	3.8	A4	8.5	Y			8405	61	30.05	34	3	90.0	3L	2300	1.4	88.0	3L	2400	2.8	N			N				
															2	91.0	3U	3300	1.8												
															4	89.0	3L	2400	1.4												
															5	88.0	3U	3300	1.8												

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VEHICLE DESCRIPTION												WEATHER			OCTANE NUMBER REQUIREMENT DATA									TANK FUEL INFORMATION							
																MAXIMUM				PART-THROTTLE							RATER				
									SPARK ADVANCE																OCT NO						
OBS. NO.	YPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	AS RCD	AS TST	ODOM MILES	AMB TMP	BAROM	HUM	FUEL	OCT NO	GEAR	RPM	VAC	OCT NO	GEAR	RPM	VAC	OWKNK	RES	MOTR	KNINT	THR	GEAR	RPM	VAC
23-07	C	F	Y	P	3.8	A4	8.5	Y			16691	68	29.10	40	3	85.0	3U	3300	1.0	85.0	3U	2900	3.0								
															2	85.0	2U	2500	1.0	85.0	3U	2500	4.0								
															4	84.0	3U	2800	1.0												
															5	84.0	3U	2800	1.0												
28-05	C	F	Y	P	3.8	A4	8.5	Y			16700	70	29.36	50	3	84.0	2U	2000	0.5	F											
															2	84.0	2U	2100	0.5												
															4	82.0	2U	2000	0.5												
															5	L				L											
46-01	C	E	Y	P	3.8	A4	8.5	Y			7332	70	28.60	0	3	87.0	2U	2050	1.0	F				N	93.4	88.7	N				
															2	87.0	2U	2450	1.0												
															4	84.0	2U	2400	1.0												
															5	87.0	2U	3025	1.0												
41-27	C	C	Y	P	3.8	A4	8.5	Y			11717	61	30.12	55	3	89.0	3U	2400	1.2	90.0	3L	2150	4.0								
															2	90.0	3U	2200	1.2	90.0	3L	1950	2.9								
															4	86.0	3U	2500	1.2												
															5	84.0	3U	2500	1.2												
47-21	C	C	Y	P	4.0	A4	10.0	Y			14524	70	30.04	50	3	91.0	2U	4000	0.6	94.0	4U	1300	13.0								
															2	93.5	2U	4500	0.6	H	4U	1350	13.0								
															4	90.0	2U	2250	0.6												
															5	89.0	2U	2250	0.6												
28-01	C	F	N	P	4.6	A4	9.0	Y			18295	70	29.76	50	3	91.0	4	1200	0.5	91.0	4	1200	1.5								
															2	93.0	2	3600	0.5												
															4	91.0	4	1200	0.5												
															5	91.0	4	1200	0.5												
07-06	C	F	N	P	4.6	A4	9.0	Y			7775	73	29.96	0	3	91.0	4	1400						N			N				
															2	93.0	4	1400													
															4	91.0	4	1400													
															5	92.0	4	1400													
32-02	C	F	N	P	4.6	A4	9.0	Y	+10	+10	8000	70	29.70	50	3	94.0	4	1500	0.5	94.0	4	1350	2.0	N	96.9	87.7	N				
															2	94.0	4	1600	0.5	94.0	4	1500	2.0								
															4	94.0	4	1500	0.5	94.0	4	1300	2.0								
															5	94.0	4	1400	0.5	94.0	4	1200	2.0								
32-14	C	F	N	P	4.6	A4	9.0	Y	+10	+10	30786	70	29.42	50	3	94.0	4	1600	1.0	94.0	4	1400	2.0	N			B	M	4	1500	1.0
															2	95.0	4	1500	1.0	95.0	4	1450	2.0								
															4	94.0	4	1500	1.0	94.0	4	1400	2.0								
															5	93.0	4	1500	1.0	93.0	4	1400	2.0								
08-10	C	F	N	P	4.9	A4	9.5	Y	+10	+10	20314	75	29.79	77	3	96.0	4U	2300	1.5	96.0	3U	2200	5.0								
															2	98.0	2U	2950	0.6	94.0	3U	2350	5.0								
															4	94.0	2U	2750	0.6												
															5	98.0	2U	2750	0.6												
28-06	C	F	N	P	4.9	A4	9.5	Y	+10	+10	16491	70	29.25	50	3	93.0	4L	1100	1.5	90.0	4L	1100	9.0								
															2	94.0	4L	1100	1.5												
															4	91.0	4L	1100	1.5												
															5	90.0	4L	1100	1.5												

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OBS. NO.	VEHICLE DESCRIPTION TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE AS RCD	AS TST	ODOM MILES	WEATHER AMB TMP	BAROM	HUM	FUEL	MAXIMUM OCT NO	GEAR	RPM	VAC	PART-THROTTLE OCT NO	GEAR	RPM	VAC	TANK FUEL INFORMATION OWKNK	OCT NO RES	OCT NO MOTR	RATER KNINT	TTHR	GEAR	RPM	VAC
23-16	C	F	N	P	4.9	A4	9.5	Y	0	0	7287	54	29.15	28	3	90.0	4L	1800	1.8	90.0	3U	2800	2.5								
															2	91.0	2U	3500	1.5	91.0	3U	2800	2.5								
															4	90.0	4L	1800	1.8	90.0	4L	1800	2.8								
															5	90.0	4L	1800	1.8	90.0	4L	1800	2.8								
23-29	C	F	N	P	4.9	A4	9.5	Y	+10	+10	16191	62	29.05	44	3	95.0	4L	1800	1.5	95.0	4L	1800	2.5								
															2	94.0	4L	1700	1.5	93.0	4L	1700	3.0								
															4	93.0	4L	1700	1.5	93.0	4L	1700	2.5								
															5	94.0	4L	1700	1.5	96.0	4L	1800	2.5								
07-04	C	F	N	P	4.9	A4	9.5	Y			20929	74	30.05	0	3	91.0	4L	1700						Y			A	M	4L	1700	
															2	92.0	2U	3000													
															4	91.0	4L	1900													
															5	91.0	4L	1700													
47-24	C	C	N	P	4.9	A4	9.5	Y	+10	+10	6204	70	29.88	50	3	94.0	4L	1500	1.5	H	4L		12.5								
															2	94.0	4L	1500	1.5	H	4L		12.5								
															4	94.0	4L	1550	1.5	94.0	4L	1550	12.5								
															5	94.0	4L	1550	1.5	H	4L		12.5								
47-18	C	C	N	P	4.9	A4	9.5	Y	+10	+10	6900	70	29.89	50	3	92.0	4L	1750	0.8	H	4L	1450	12.5	O	97.8	86.2	A	P	4L	1800	15.
															2					H	4L	1450	12.5								
															4	92.0	4L	1750	0.8	92.0	4L	1750	3.5								
															5	92.0	4L	1650	0.8	105.0	4L	1400	12.5								
47-20	C	C	N	P	4.9	A4	9.5	Y	+10	+10	11920	70	30.12	50	3	93.5	4L	1750	0.8	H	4L	1250	11.0								
															2	95.0	4L	1750	0.8	H	4L	1250	11.0								
															4	93.0	4L	1750	0.8	93.0	4L	1250	11.0								
															5	93.0	4L	1750	0.8	H	4L	1250	11.0								
05-29	C	F	N	P	4.9	A4	9.5	Y	+10	+10	15876	70	29.50	27	3	97.0	2U	3850	0.8	95.0	4L	1150	8.0								
															2	98.0	2U	3700	0.8												
															4	96.0	2U	3800	0.8												
															5	95.0	2U	3850	0.8												
08-07	C	F	N	P	4.9	A4	9.5	Y	+10	+10	15791	78	30.07	72	3	91.0	2U	3050	0.5	89.0	3U	1750	11.5								
															2	92.0	2U	2900	0.5	90.0	3U	1900	11.5								
															4	88.0	2U	3150	0.5												
															5	86.0	4U	2700	2.3	L											
23-08	C	F	N	P	4.9	A4	9.5	Y	+10	+10	7016	77	29.30	74	3	91.0	2U	3300	1.0	F											
															2	92.0	2U	3900	1.0												
															4	87.0	2U	3100	1.0												
															5	89.0	2U	3200	1.0												
32-10	C	F	N	P	5.0	M5	9.0	Y	+10	+10	8026	70	29.47	50	3	89.0	4	1700	0.5	89.0	4	1300	4.0	N			N				
															2	90.0	4	1800	0.5	90.0	4	1400	4.0								
															4	89.0	4	1700	0.5	89.0	4	1300	4.0								
															5	88.0	4	1800	0.5	88.0	4	1400	4.0								
28-29	C	F	N	P	5.0	A4	8.3	Y	+10	+10	20024	70	29.28	50	3	87.0	4	1100	1.5	85.0	4	1100	2.5								
															2	88.0	4	1100	1.5												
															4	87.0	4	1300	1.5												
															5	87.0	4	1200	1.5												

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	VEHICLE DESCRIPTION											WEATHER			OCTANE NUMBER REQUIREMENT DATA									TANK FUEL INFORMATION							
																MAXIMUM				PART-THROTTLE							RATER				
									SPARK ADVANCE																						
OBS. NO.	TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	AS RCD	AS TST	ODOM MILES	AMB TMP	BAROM	HUM	FUEL	OCT NO	GEAR	RPM	VAC	OCT NO	GEAR	RPM	VAC	OWKNK	OCT NO RES	OCT NO MOTR	KNINT	THR	GEAR	RPM	VAC
32-08	C	F	N	P	5.0	A4	8.3	Y	+ 9	+ 9	20583	70	29.60	50	3	92.0	3	2100	0.3	90.0	3	1700	2.0	N			B	M	2	2500	0.5
															2	93.0	3	2200	0.3	91.0	3	1600	2.0								
															4	92.0	3	2200	0.3	90.0	3	1600	2.0								
															5	91.0	3	2200	0.3	89.0	4	800	4.0								
08-16	C	F	Y	T	5.0	A4	9.3	Y	0	0	7352	76	30.05	61	3	92.0	2U	1750	0.6	92.0	4L	900	12.0								
															2	92.0	2U	1900	0.6	93.0	4L	900	12.0								
															4	90.0	4U	1850	1.0												
															5	90.0	4U	1900	1.0												
28-07	C	F	Y	T	5.0	A4	9.3	Y	0	0	20227	70	29.46	50	3	94.0	2U	3800	0.5	91.0	4U	1600	2.0								
															2	99.0	2U	3800	0.5												
															4	92.0	4U	1700	1.0												
															5	92.0	2U	2300	0.5												
29-03	C	F	Y	T	5.0	A4	9.3	Y	0	0	6841	70	29.62	50	3					99.0	3L	1300	12.0								
															2					100.0	3L	1300	12.0								
															4	90.0	3U	1500	1.4												
															5					99.0	3L	1300	12.0								
05-01	C	F	Y	T	5.0	A4	9.3	Y			17600	70	29.75	50	3	92.0	3U	2200	0.8	93.0	2U	1300	15.0								
															2	91.0	4U	1930	0.8	92.0	2U	1300	15.0								
															4	91.0	3U	1980	0.8												
															5	89.0	3U	1880	0.8												
23-06	C	F	Y	T	5.0	A4	9.3	Y	0	0	9414	57	29.02	42	3	88.0	3L	1200	4.0	88.0	3U	1700	3.0								
															2	88.0	3L	1200	4.0												
															4	88.0	3U	1750	1.0	88.0	3U	1750	3.0								
															5	88.0	3U	1700	1.0	88.0	3U	1700	3.0								
23-24	C	F	Y	T	5.0	A4	8.0	Y	0	0	16810	40	29.02	15	3	91.0	2U	4300	1.0	F											
															2	96.0	2U	4000	1.0												
															4	88.0	3U	1800	1.0												
															5	88.0	3L	1800	1.0	88.0	3L	1700	2.0								
23-11	C	F	Y	P	5.7	M6	9.5	Y	+ 6	+ 6	12340	76	29.68	74	3	94.0	4	2700	0.0	94.0	4	1300	2.0								
															2	94.0	4	3000	0.0	94.0	4	2500	3.0								
															4	92.0	4	3000	0.0												
															5	94.0	4	3000	0.0	94.0	5	1500	2.0								
29-13	T	F	N	P	2.3	A4	9.2	N	+10	+10	9686	75		74	3	90.0	3U	2300	0.8	88.5	4L	2400	2.0								
															2	90.0	3U	2500	0.8												
															4	91.5	3L	2300	0.8												
															5	89.0	4L	2500	1.0												
47-19	T	C	Y	P	2.4	A4	9.3	Y	+ 5	+ 5	17980	70	30.15	50	3	93.0	2U	2500	1.0	L											
															2	94.0	2U	3500	1.0												
															4	92.0	2U	2500	1.0												
															5	91.0	2U	2500	1.0												
60-04	T	F	Y	P	2.4	A4	9.3	Y	+ 5	+ 5	17246	78	29.50	48	3	86.0	3U	2500	0.7	85.0	3U	2400	1.0								
															2	84.0	4U	2300	0.9	84.0	4U	2300	1.4								
															4	86.0	3U	2300	0.8												
															5	86.0	3U	2300	0.8												

1991 CRC OCTANE NUMBER REQUIREMENT SURVEY

OBS. NO.	TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE AS RCD	SPARK ADVANCE AS TST	ODOM MILES	AMB TMP	BAROM	HUM	FUEL	MAXIMUM OCT NO	MAXIMUM GEAR	MAXIMUM RPM	MAXIMUM VAC	PART-THROTTLE OCT NO	PART-THROTTLE GEAR	PART-THROTTLE RPM	PART-THROTTLE VAC	OWKNK	OCT NO RES	OCT NO MOTR	RATER KNINT	RATER THR	RATER GEAR	RATER RPM	RATER VAC
41-17	T	C	Y	P	2.4	M5	9.3	Y	+ 5	+ 5	6387	69	30.20	60	3	98.0	3	2700	0.6	99.0	3	2800	2.0	N	92.0	82.9	B	P	3	2500	0.
															2	97.0	3	2500	0.6	98.0	3	2400	2.4								
															4	99.0	3	2600	0.6	100.0	3	2450	2.4								
															5	102.0	3	2700	0.6	102.0	3	2550	2.2								
05-06	T	F	N	T	2.5	M5	8.3	Y	+ 8	+ 8	13340	70	30.00	50	3					103.0	4	1900	9.0	Y	98.1		B	M	4	1780	0.
															2					99.0	4	1990	9.0								
															4	91.0	4	1900	0.2												
															5					101.0	3	1300	8.0								
23-22	T	F	N	T	2.5	A4	8.3	Y			6835	38	28.96	30	3	87.0	4L	1800	1.0	F											
															2	86.0	4L	2000	1.0												
															4	85.0	4L	1800	1.0												
															5	86.0	4L	1800	1.0												
23-23	T	F	N	T	2.5	A4	8.3	Y			6237	46	29.04	31	3	84.0	4L	1750	1.0	80.0	4L	1750	2.0								
															2	86.0	4L	1750	1.0												
															4	84.0	4L	1750	1.0												
															5	84.0	4L	1750	1.0												
41-15	T	C	N	P	2.6	M5	8.3	N	+12	+12	11485	65	30.00	38	3	98.0	3	2850	0.6	98.0	3	2750	2.5	N	92.8	82.5	B	P	4	2900	2.
															2	99.0	3	2800	0.6	99.0	3	2800	2.3								
															4	98.0	3	2800	0.6	98.0	3	2700	2.4								
															5	99.0	3	2700	0.6	98.0	3	2800	2.6								
23-25	T	F	Y	T	2.8	M5	8.9	Y	+10	+10	6996	45	29.12	16	3	84.0	4	2000	0.5	84.0	4	2000	1.5								
															2	84.0	4	2500	0.5	84.0	4	2500	1.5								
															4	85.0	4	1500	0.5	85.0	4	1500	1.5								
															5	84.0	4	1500	0.5	84.0	4	1500	1.5								
29-26	T	F	N	P	3.0	A3	8.9	Y	+12	+12	14778	70	29.38	54	3	90.0	3L	2050	1.0	91.0	3L	2000	6.0								
															2	92.0	3L	2150	1.0	93.0	3L	2000	6.0								
															4	87.0	3U	2700	1.5												
															5	90.0	3U	3000	1.5												
32-03	T	F	N	P	3.0	M5	9.3	Y	+11	+11	21701	70	29.63	50	3	93.0	3	4700	1.0	93.0	3	4800	2.0	Y	92.0	83.2	B	P	4	1500	2.
															2	94.0	3	4500	1.0	94.0	3	4750	2.0								
															4	93.0	3	4750	1.0	93.0	3	4850	2.0								
															5	92.0	3	4600	1.0	92.0	3	4850	2.0								
05-07	T	F	N	P	3.0	A4	9.3	N	+10	+10	16080	70	30.00	50	3	92.0	3U	2560	1.0	F				Y	93.2	81.9	B	M	4L	2250	1.
															2	93.0	4L	1980	1.0												
															4	91.0	4L	2300	1.0												
															5	90.0	3U	3100	1.0												
40-01	T	F	N	P	3.0	A4	8.5	N	+11	+11	7843	91	29.98	120	3	89.0	3U	2700	1.0	88.0	4L	2200	3.0								
															2	91.0	3U	2800	1.0												
															4	86.0	3U	2900	1.0												
															5	88.0	3U	3100	1.0												
62-02	T	F	N	P	3.0	A4	9.0	Y	+18	+15	16465	76	29.48	35	3	82.0	3U	2700	0.9	80.0	4U	2500	2.4								
															2	83.0	3U	2700	0.9	83.0	3U	2900	2.0								
															4	83.0	3U	2750	0.9												
															5	85.0	3U	2500	0.9												

1991 CRC OCTANE NUMBER REQUIREMENT SURVEY

	VEHICLE DESCRIPTION											WEATHER			OCTANE NUMBER REQUIREMENT DATA									TANK FUEL INFORMATION							
																MAXIMUM				PART-THROTTLE							RATER				
OBS. NO.	TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE AS RCD	SPARK ADVANCE AS TST	ODOM MILES	AMB TMP	BAROM	HUM	FUEL	OCT NO	GEAR	RPM	VAC	OCT NO	GEAR	RPM	VAC	OWKNK	OCT NO RES	OCT NO MOTR	KNINT	THR	GEAR	RPM	VAC
08-23	T	F	Y	T	3.1	A3	8.5	Y	+10	+10	12307	74	29.97	55	3	82.0	3U	2450	2.5	80.0	3L	1750	5.0								
															2	84.0	3U	2450	2.5												
															4	81.0	2U	2600	1.5												
															5	L				L											
05-18	T	F	Y	P	3.3	A4	8.9	Y			21629	70	30.01	40	3	88.0	3U	2600	0.5	F				N	91.3	81.6	N				
															2	90.0	3U	2050	0.5												
															4	86.0	3U	2550	0.5												
															5	85.0	3U	2500	0.5												
28-08	T	F	Y	P	3.3	A4	8.9	Y			18461	70	29.38	50	3	84.0	3U	2400	0.5	83.0	3U	2000	2.0								
															2	86.0	3U	2300	0.5												
															4	82.0	2U	2500	0.5												
															5	L															
29-14	T	F	N	T	3.9	A4	9.2	Y	+10	+10	16032	74		63	3	91.5	3U	2800	1.0	91.5	4L	1900	2.0								
															2	92.0	3U	2800	1.0												
															4	90.0	4L	1900	1.0												
															5	90.0	4L	1700	1.0												
41-09	T	C	N	P	4.0	A4	8.9	Y	+12	+12	13495	62	30.30	60	3	103.0	4L	1700	1.0	103.0	4L	1700	4.0								
															2	H	4L	1650	1.0	H	4L	1700	4.0								
															4	H	4L	1650	1.0	H	4L	1500	4.0								
															5	105.0	4L	1600	1.0	105.0	4L	1650	3.0								
41-28	T	C	N	P	4.0	M5	9.0	Y			18133	70	30.29	38	3	94.0	3	3800	0.4	92.0	3	3800	1.6	N	92.7	81.4	A	M	4	2200	0.2
															2	95.0	3	3650	0.4												
															4	94.0	4	2350	0.2												
															5	92.0	4	2200	0.2	94.0	3	2150	2.0								
46-07	T	E	N	P	4.0	M5	9.0	Y	+10	+10	22722	71	29.38	87	3	88.0	4	1750	1.0	84.0	4	1350	2.0	N							
															2	89.0	4	1850	1.0												
															4	89.0	4	1500	1.0												
															5	87.0	4	1350	1.0												
32-01	T	F	N	P	4.0	A4	9.0	Y	+10	+10	18557	70	29.75	50	3	89.0	3L	2450	1.0	89.0	3L	2600	2.0	O	91.9	83.2	N				
															2	90.0	3L	2600	1.0	90.0	3L	2650	2.0								
															4	89.0	3L	2600	1.0	89.0	3L	2700	2.0								
															5	88.0	3L	2600	1.0	88.0	3L	2700	2.0								
32-04	T	F	N	P	4.0	A4	9.0	Y	+10	+10	7854	70	29.03	50	3	88.0	3L	2450	1.0	88.0	3L	2500	2.0	N	93.3	84.0	N				
															2	89.0	3L	2450	1.0	89.0	3L	2400	2.0								
															4	88.0	3L	2500	1.0	88.0	3L	2350	2.0								
															5	87.0	3L	2500	1.0	87.0	3L	2100	2.0								
47-14	T	C	N	P	4.0	A4	9.0	Y			29625	70	30.06	50	3	90.0	4L	2150	0.8	87.0	4L	2150	1.8								
															2	90.0	4L	2150	0.8												
															4	88.0	4L	2200	0.8												
															5	88.0	4L	2200	0.8												
05-11	T	F	N	P	4.0	A4	9.0	N	+10	+10	13900	70	29.71	50	3	92.0	4U	3080	1.4	F				N	91.7	81.8	A	M	4U	2840	1.[illegible]
															2	93.0	4U	3150	1.4												
															4	90.0	4U	2970	1.4												
															5	91.0	4U	2970	1.4												

1991 CRC OCTANE NUMBER REQUIREMENT SURVEY

OBS. NO.	VEHICLE DESCRIPTION: TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE: AS RCD	AS TST	ODOM MILES	WEATHER: AMB TMP	BAROM	HUM	OCTANE NUMBER REQUIREMENT DATA: FUEL	MAXIMUM: OCT NO	GEAR	RPM	VAC	PART-THROTTLE: OCT NO	GEAR	RPM	VAC	TANK FUEL INFORMATION: OWKNK	OCT NO: RES	MOTR	RATER: KNINT	THR	GEAR	RPM	VAC
28-02	T	F	N	P	4.0	A4	9.0	Y	+10	+10	17840	70	29.46	50	3	89.0	4L	1800	1.0	91.0	4L	1700	5.0								
															2	93.0	2U	4300	0.5	93.0	4L	1700	5.0								
															4	89.0	4L	2000	0.8												
															5	89.0	4L	1800	1.0	89.0	4L	1700	5.0								
32-07	T	F	N	P	4.0	A4	9.0	Y	+12	+12	19573	70	29.78	50	3	90.0	4L	1600	1.0	93.0	4L	1500	6.0	N			B	P	4L	:500	6.
															2	91.0	4L	1600	1.0	93.0	4L	1500	6.0								
															4	90.0	4L	1600	1.0	92.0	4L	1500	6.0								
															5	89.0	4L	1600	1.0	92.0	4L	1500	6.0								
05-26	T	F	N	P	4.0	A4	9.0	Y	+10	+10	30680	70	30.00	39	3	92.0	4U	2600	1.0	F											
															2	93.0	4U	2600	1.0												
															4	91.0	4U	2700	1.0												
															5	91.0	4U	2550	1.0												
23-01	T	F	Y	T	4.3	A4	9.3	Y	0	0	9320	70	29.64	66	3	84.0	3L	1700	0.5	84.0	3L	1700	2.0								
															2	82.0	3L	1700	0.5												
															4	82.0	2U	2100	0.2												
															5	L				L											
23-03	T	F	Y	T	4.3	M5	9.3	Y	0	0	6435	67	29.11	60	3	82.0	4	1200	0.4	L											
															2	82.0	4	1200	0.4	82.0	3	3000	2.0								
															4	82.0	4	1400	0.4												
															5	L				L											
07-02	T	F	Y	T	4.3	A4	9.3	Y			15877	73	29.92	0	3	88.0	3U	2100						N			N				
															2	87.0	3U	2200													
															4	88.0	2U	2700													
															5	87.0	3U	2200													
29-12	T	F	Y	T	4.3	A4	9.3	Y	0	0	6550	74	29.50	56	3	89.5	3U	2500	0.8	88.0	4L	1500	2.5								
															2	90.5	2U	3000	1.0												
															4	88.0	3U	2300	0.8												
															5	88.0	3U	2300	0.8												
47-04	T	C	Y	T	4.3	A4	9.3	Y	+ 4	0	15660	70	29.89	54	3	91.0	2U	2000	0.4	88.0	4L	1500	1.8								
															2	92.0	2U	2000	0.4												
															4	90.0	2U	2000	0.4												
															5	88.0	2U	1800	0.4												
47-11	T	C	Y	T	4.3	A4	9.3	Y	0	0	12150	70	29.89	50	3	91.0	2U	2000	0.8	F											
															2	92.0	2U	3500	0.8												
															4	90.0	2U	1500	0.8												
															5	88.0	2U	2000	0.8												
41-18	T	C	Y	T	4.3	A4	9.3	Y	0	0	20691	71	30.06	54	3	96.0	3L	2100	0.8	F											
															2	96.0	3L	2200	0.8												
															4	96.0	3U	2050	0.2												
															5	95.0	3L	2000	0.8												
23-18	T	F	Y	T	4.3	A4	9.3	Y	0	0	8624	57	30.08	42	3	94.0	4L	1600	1.0	93.0	3U	2800	2.0								
															2	94.0	4L	1500	1.0	94.0	4L	1500	2.0								
															4	94.0	4L	1600	1.0												
															5	94.0	3U	2800	0.5												

1991 CRC OCTANE NUMBER REQUIREMENT SURVEY

VEHICLE DESCRIPTION												WEATHER			OCTANE NUMBER REQUIREMENT DATA									TANK FUEL INFORMATION							
																MAXIMUM				PART-THROTTLE							RATER				
									SPARK ADVANCE																OCT NO						
OBS. NO.	TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	AS RCD	AS TST	ODOM MILES	AMB TMP	BAROM	HUM	FUEL	OCT NO	GEAR	RPM	VAC	OCT NO	GEAR	RPM	VAC	OWKNK	RES	MOTR	KNINT	THR	GEAR	RPM	VAC
08-05	T	F	Y	T	4.3	A4	9.3	Y	0	0	7160	72	29.75	67	3	88.0	4L	1400	1.3	86.0	3L	1350	4.0								
															2	89.0	4L	1350	1.3												
															4	87.0	4L	1400	1.3												
															5	89.0	4L	1450	1.3												
29-06	T	F	Y	T	4.3	A4	9.3	Y			17534	75	29.38	64	3	H	4L	2500	1.2	H	4L	2400	2.4								
															2	H	4L	2500	1.2												
															4	H	4L	2300	1.2												
															5	H	4L	2300	1.2												
29-27	T	F	Y	T	4.3	A4	9.3	Y	0	0	25803	74	29.55	67	3	94.0	2U	2000	1.0	93.0	4L	1500	2.5								
															2	96.0	3U	2000	1.0												
															4	95.0	4L	1200	1.5												
															5	94.0	4L	1200	1.0												
29-15	T	F	Y	T	4.3	A4	9.3	Y	0	0	18698	75	29.30	76	3	95.0	2U	2300	1.0	94.0	3L	2200	2.0								
															2	97.0	3U	1850	1.0												
															4	94.0	4L	1400	1.2												
															5	95.0	4L	1500	1.2												
05-09	T	F	Y	T	4.3	A4	9.3	Y	0	0	6872	70	30.05	50	3					95.0	2U	1800	8.0	N	94.9	85.2	B	P	2U	[illegible]	8[illegible]
															2					97.0	4L	1560	8.0								
															4	93.0	4L	1480	1.5												
															5	90.5	4L	1360	2.0	90.0	4L	1620	8.0								
23-27	T	F	Y	T	4.3	M5	9.3	Y	0	0	6812	77	29.91	98	3	85.0	4	1500	0.2	84.0	4	1600	2.0								
															2	85.0	4	1500	0.2	85.0	3	1700	2.0								
															4	86.0	4	1800	0.2	86.0	4	1700	2.0								
															5	86.0	4	1500	0.2	86.0	4	1500	2.0								
29-10	T	F	Y	P	4.9	A4	8.8	Y	+10	+10	6716	70	29.72	50	3	92.0	4L	1600	1.2	90.0	4L	1500	2.2								
															2	92.5	2U	3000	1.0												
															4	92.0	4L	1500	1.2												
															5	92.0	4L	1500	1.2												
40-03	T	F	Y	P	5.0	A4	9.0	Y	+10	+10	9964	77	29.78	60	3	95.0	4L		1.0	93.0	4L		2.5								
															2	95.0	4L		1.0												
															4	94.0	4L		1.0												
															5																
40-04	T	F	Y	P	5.0	A4	9.0	Y	+10	+10	10024	77	30.00	78	3	92.0	4L	1900	0.0	91.0	4L	1800	3.0								
															2	92.0	4L	2000	0.0	92.0	4L	1800	3.0								
															4	93.0	3U	2300	0.0												
															5	91.0	4L	2000	0.0												
23-04	T	F	Y	T	5.0	A4	9.2	Y			6315	62	29.15	44	3	87.0	2U	2500	0.5	F											
															2	88.0	2U	2800	0.4												
															4	87.0	2U	2500	0.5												
															5	87.0	2U	2400	0.5												
26-05	T	E	Y	T	5.0	A4	9.2	Y	0	0	28501	76	30.14	0	3	92.0	3U	2000	1.2												
															2	94.0	3U	1950	1.2												
															4	92.0	3U	2100	1.2												
															5	91.0	3U	1750	1.2												

1991 CRC OCTANE NUMBER REQUIREMENT SURVEY

OBS. NO.	TYPE	EMCT	KS	F/A SYS	DSP	TRANS	C.R.	AIR	SPARK ADVANCE AS RCD	SPARK ADVANCE AS TST	ODOM MILES	AMB TMP	BAROM	HUM	FUEL	MAXIMUM OCT NO	MAXIMUM GEAR	MAXIMUM RPM	MAXIMUM VAC	PART-THROTTLE OCT NO	PART-THROTTLE GEAR	PART-THROTTLE RPM	PART-THROTTLE VAC	OWKNK	OCT NO RES	OCT NO MOTR	RATER KNINT	RATER THR	RATER GEAR	RATER RPM	RATER VAC
29-08	T	F	N	T	5.2	A3	9.2	Y	+10	+10	15068	75	29.42	58	3	92.0	2U	2600	1.5	90.5	3L	1700	2.5								
															2	93.5	2U	2800	1.5												
															4	92.0	3L	1800	1.2												
															5	92.0	3L	1800	1.2												
23-17	T	F	Y	T	5.7	A4	9.1	Y	0	0	8328	47	29.17	28	3	87.0	3U	2500	1.0	87.0	3U	2500	2.0								
															2	87.0	3U	2500	1.0	87.0	3U	2500	2.0								
															4	89.0	3U	2500	1.0	89.0	3U	2500	2.0								
															5	88.0	3U	2500	1.0	88.0	3U	2400	2.0								
29-07	T	F	Y	T	5.7	A4	9.1	Y	0	0	29503	74	29.15	73	3	101.0	2U	2100	1.2	F											
															2	101.5	2U	2200	1.2												
															4	97.0	2U	2100	1.2												
															5	103.0	2U	2100	1.2												
23-30	T	F	Y	T	5.7	M5	9.1	Y	0	0	29325	52	29.36	34	3	89.0	4	1500	0.5	88.0	4	1800	2.0								
															2	89.0	4	2300	0.5	89.0	4	2300	2.0								
															4	90.0	4	2000	0.5	90.0	4	2300	2.0								
															5	90.0	4	2000	0.5												
29-09	T	F	Y	T	5.7	A4	9.1	Y	0	0	12334	70	29.72	50	3	86.0	2U	2200	1.5	F											
															2	87.0	2U	2000	1.5												
															4	86.0	2U	2100	1.5												
															5	86.0	2U	2200	1.5												
46-05	T	E	Y	T	5.7	A4	9.1	Y	0	0	10550	73	29.45	56	3	85.0	3U	2200	1.0	F				N							
															2	86.0	3L	2370	1.0												
															4	85.0	3U	2400	1.0												
															5	85.0	3U	2250	1.0												
47-25	T	C	Y	T	5.7	A4	9.1	Y	0	0	8100	70	29.93	50	3	96.0	4L	2000	2.0	94.0	4L	2000	2.0								
															2	97.0	4L	2000	2.0												
															4	89.0	4L	2000	2.0												
															5	93.0	4L	1700	2.0												
41-05	T	C	Y	T	5.7	A4	9.1	Y	0	0	18515	65	30.08	54	3	103.0	4U	2350	1.8	103.0	4U	2250	3.4								
															2	103.0	4U	2300	1.8	103.0	4U	2250	3.0								
															4	100.0	4U	2400	1.8	100.0	4U	2250	3.0								
															5	105.0	4U	2350	1.8	105.0	4U	2250	3.2								
23-02	T	F	Y	T	5.7	M4	9.1	Y	0	0	17486	58	29.62	32	3	L				L											
															2	82.0	3	1500	1.0	82.0	3	1500	2.0								
															4	81.0	3	1500	1.0	81.0	3	1500	2.0								
															5	L				L											

APPENDIX F

PROCEDURES FOR CALCULATING AND PLOTTING OCTANE NUMBER REQUIREMENT DISTRIBUTION DATA

WEIGHTED VEHICLE POPULATIONS

Weighting factors for each model tested were proportioned to the productions and/or sales volumes developed from information supplied by U.S. vehicle manufacturers and from published information (Ward's Automotive Reports) for imports. The weighting factors of each vehicle model were divided by the number of vehicles tested within the model to calculate the individual vehicle weighting factor. The octane requirement for each vehicle were then arranged in increasing order. The percent of vehicles at each octane level is the summation of all vehicle weighting factors with octane requirements lower than that level, plus one-half the sum of the weighting factors at that level. The individual vehicle weighting factors are adjusted so that the summation of all vehicle weighting factors within the population of interest equals 100. Vehicle weighting factors for vehicles with octane requirements lower (L) than the lowest available fuel are assigned to the beginning of the distribution while weighting factors for vehicles with octane requirements higher (H) than the highest test fuel are assigned above the highest test fuel octane level. For L and H octane requirements no octane value is used in the computation of octane satisfaction.

Octane satisfaction at population distribution points of interest is interpolated from the above distributions based on numeric octane data and an assumption of normal distribution between the two interpolation points.

DATA ROUND-OFF

The octane number requirements were rounded by the computer to one decimal place. All computations leading to the final rounded values were carried out at the full precision of the computer. In previous surveys the computer rounded requirement data to two decimal places. In preparing report tables the Analysis Panel rounded the computer decimal requirements to one decimal place.

In order to provide consistent treatment comparing 1990 and 1991 survey data, the 1991 data were recomputed and rounded to one decimal place by the computer. This can result in occasional small differences (e.g. $\pm$ 0.1) if a comparison is made using the data in the 1991 survey report.

SELECT CAR MODELS

For individual models, the octane number requirement distribution curves were plotted by the "S" method as described in "Statistical Estimation of the Gasoline Octane Number Requirement of New Model Automobiles," C. S. Brinegar and R. R. Miller, Technometrics, Vol. 2, No. 1, February 1960.

The procedure is as follows:

For any vehicles having octane requirements lower (L) than the lowest octane number fuel available within a given fuel level, a number 0.5 Research/0.4 Motor lower was assigned. Similarly, for individual vehicles having octane requirements higher (H) than the highest octane fuel available within a given fuel series, a number 0.5 Research/0.4 Motor higher was assigned.

Using all observed and estimated octane number values, calculate the mean ($\overline{X}$) and the standard deviation (s) from the data for each model.

$$s = \left[\frac{1}{n-1} \sum_{i=1}^{n} (X_i - \overline{X})^2 \right]^{1/2}$$

Where X_i = Octane number requirement of i^{th} car of a given model

n = Number of cars of that model.

Estimate octane number requirements at the percentiles of interest from octane number requirement distribution data by

$$O.N. = \overline{X} + ks$$

Where k is selected from normal distribution tables.

Values of k used to calculate percentiles in this report are:

Percentile	k
5	-1.645
10	-1.282
20	-0.842
30	-0.524
40	-0.253
50	0
60	+0.253
70	+0.524
80	+0.842
90	+1.282
95	+1.645

APPENDIX G

CONFIDENCE LIMITS OF OCTANE NUMBER REQUIREMENT DISTRIBUTIONS

CONFIDENCE LIMITS OF OCTANE NUMBER REQUIREMENT DISTRIBUTIONS

Octane number requirements of vehicles presented in this Survey are determined at the levels that satisfy certain percentages of specific vehicle populations. In many cases, the recorded octane number requirement is followed by a plus and minus limit, referred to as the confidence interval. These limits are expected to bound the true requirement of the population represented by the test vehicles 95 percent of the time in replicate testing of the same number of test vehicles.

At the 50 percent satisfaction level, the 95 percent confidence interval is calculated as follows:

$$CI = \pm ts/(n)^{1/2}$$

where t = Students t at the proper number of degrees of freedom*

s = Standard deviation, calculated directly from the data or estimated as the difference between the 84.16th and 50th percentiles (assuming normal distribution)

n = Number of vehicles in population.

At other satisfaction levels:

$$CI = \pm ts[1/n + k^2/[2(n-1)]]^{1/2}$$

At the 90 percent satisfaction level, k = 1.2817. For other satisfaction levels, appropriate values for k may be found in the standard statistical tables.

Degrees of Freedom**	t	Degrees of Freedom**	t
1	12.706	18	2.101
2	4.393	19	2.093
3	3.182	20	2.086
4	2.776	21	2.080
5	2.571	22	2.074
6	2.447	23	2.069
7	2.365	24	2.064
8	2.306	25	2.060
9	2.262	26	2.056
10	2.228	27	2.052
11	2.201	28	2.048
12	2.179	29	2.045
13	2.160	30	2.042
14	2.145	40	2.021
15	2.131	60	2.000
16	2.120	120	1.980
17	2.110	∞	1.960

* Distribution of t for probability = 0.05.

** Degrees of Freedom = (n-1).

TABLE G-I

95% CONFIDENCE LIMITS FOR MAXIMUM OCTANE NUMBER REQUIREMENTS

1991 Weighted Population Groups

				Standard Dev.			95% Confidence Limits					
							RON		MON		(R+M)/2	
Population	Fuel	No. Veh.	t	RON	MON	(R+M)/2	50%	90%	50%	90%	50%	90%
Total 1991 Vehicles												
	PR	255	1.969	4.37	4.37	4.37	0.54	0.73	0.54	0.73	0.54	0.73
	FBRU	262	1.969	4.77	3.03	3.90	0.58	0.78	0.37	0.50	0.47	0.64
	FBRSU	262	1.969	4.82	3.50	4.16	0.59	0.79	0.43	0.57	0.51	0.68
	FBRUM	255	1.969	5.31	2.66	3.98	0.66	0.89	0.33	0.44	0.49	0.66
Passenger Cars												
	PR	199	1.972	3.88	3.88	.88	0.54	0.73	0.54	0.73	0.54	0.73
	FBRU	206	1.972	4.84	3.02	3.93	0.66	0.90	0.42	0.56	0.54	0.73
	FBRSU	206	1.972	4.75	3.40	4.07	0.65	0.88	0.47	0.63	0.56	0.75
	FBRUM	200	1.972	5.36	2.68	4.02	0.75	1.01	0.37	0.51	0.56	0.76
Light-Duty Trucks & Vans												
	PR	56	2.003	5.20	5.20	5.20	1.39	1.89	1.39	1.89	1.39	1.89
	FBRU	56	2.003	5.35	3.58	4.46	1.43	1.94	0.96	1.30	1.19	1.62
	FBRSU	56	2.003	5.02	3.82	4.42	1.34	1.82	1.02	1.39	1.18	1.60
	FBRUM	55	2.004	6.01	3.12	4.56	1.62	2.20	0.84	1.14	1.23	1.67
Knock-Sensor Vehicles												
	PR	102	1.983	5.43	5.43	5.43	1.07	1.44	1.07	1.44	1.07	1.44
	FBRU	105	1.982	6.25	3.98	5.11	1.21	1.63	0.77	1.04	0.99	1.33
	FBRSU	105	1.982	6.84	4.85	5.84	1.32	1.79	0.94	1.27	1.13	1.53
	FBRUM	103	1.982	5.05	2.53	3.79	0.99	1.34	0.49	0.67	0.74	1.00